CHAPTER 7

BRAKES

INTRODUCTION

Learning Objective: Explain the hydraulic and mechanical principles of a brake system. Describe and define the major components of hydraulic, air, and air-over-hydraulic brake systems. Explain the operation of hydraulic, air, and air-over-hydraulic brake systems. Summarize the operation of antilock braking systems.

The brake system is the most important system on a vehicle from a safety standpoint. You, as the mechanic, are trusted to do every service and repair operation correctly. When working on a brake system, always keep in mind that a brake system failure could result in a fatal vehicle accident. It is up to you to make sure the vehicle brake system is in perfect operating condition before the vehicle leaves the shop.

Braking action is the use of a controlled force to accomplish three basic tasks—to slow down, stop, or hold the wheels of a vehicle stationary. Braking action is accomplished by rubbing two surfaces together that cause friction and heat (fig. 7-1). Friction is the resistance to relative motion between two surfaces in contact. The brakes convert kinetic (moving) energy into heat to stop the vehicle. Heat energy is an unwanted product of friction and must be dissipated to the surrounding environment as efficiently as possible.

HYDRAULIC BRAKE SYSTEM

Learning Objective: Describe the operation, terms, and component functions of a hydraulic brake system. Describe the procedures for servicing a hydraulic brake system.

In hydraulic braking systems, the pressure applied at the brake pedal is transmitted to the brake mechanism by a liquid. To understand how pressure is transmitted by a hydraulic braking system, it is necessary to understand the fundamentals of hydraulics (refer to chapter 3 of this TRAMAN). There are two common types of hydraulic brake systems used on modern vehicles—drum and disc brakes.

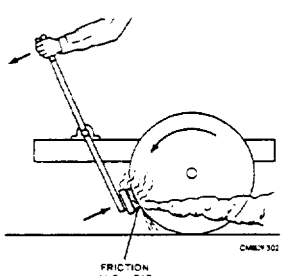


Figure 7-1.—Development of friction and heat.

PRINCIPLES OF BRAKING

It is known that to increase the speed of a vehicle requires an increase in the power output of the engine. It is also true, although not so apparent, that an increase in speed requires an increase in the braking action to bring a vehicle to a stop (fig. 7-2). A moving vehicle, just as any other moving body, has what is known as kinetic energy. Kinetic energy is the energy an object possesses due to its relative motion. This kinetic energy, which increases with speed, must be overcome by braking action. If the speed of the vehicle is doubled, its kinetic energy is increased fourfold; therefore, four times as much energy must be overcome by the braking action.

Brakes must not only be capable of stopping a vehicle but must stop in as short a distance as possible. Because brakes are expected to decelerate a vehicle at a faster rate than the engine can accelerate, they must be able to control a greater power than that developed

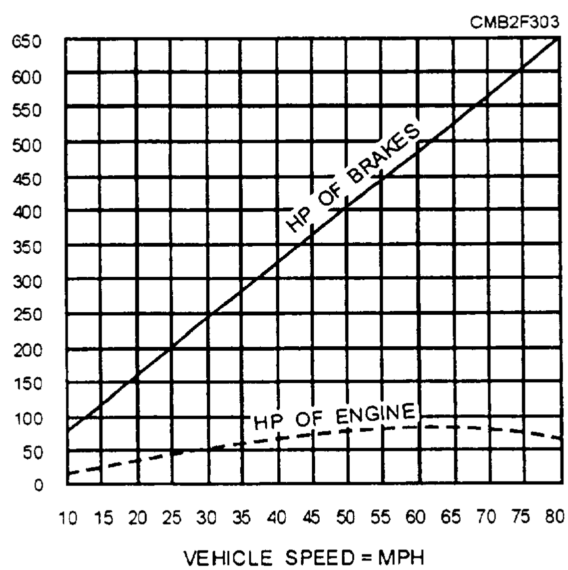


Figure 7-2.—Braking requirements.

by the engine. This is the reason that well-designed, powerful brakes have to be used to control the modern high-speed vehicle.

It is possible to accelerate an average vehicle with an 80 horsepower engine from a standing start to 80 mph in about 36 seconds. By applying the full force of the brakes, such a vehicle can be decelerated from 80 mph to a full stop in about 4.5 seconds. The time required to decelerate to a stop is one eighth of the time required to accelerate from a standing start. Therefore, the brakes harness eight times the power developed by the engine. Thus about 640 (8 x 80) horsepower has to be spent by the friction surfaces of the brakes of an average vehicle to bring it to a stop from 80 mph in 4.5 seconds.

Vehicle Stopping Distance

Operator reaction time is the time frame between the instant the operator decides that the brakes should be applied and the moment the brake system is activated. During the time that the operator is thinking about applying the brakes and moving his or her foot to do so, the vehicle will travel a certain distance depending on the speed of the vehicle. After the brakes are applied, the vehicle will travel an additional distance before it is brought to a stop.

Total stopping distance of a vehicle is the total of the distance covered during the operator's reaction time and the distance during which the brakes are applied before the vehicle stops. Figure 7-3 shows the total stopping distance required at various vehicle speeds, assuming the average reaction time of 3/4 second and that good brakes are applied under most favorable road conditions.

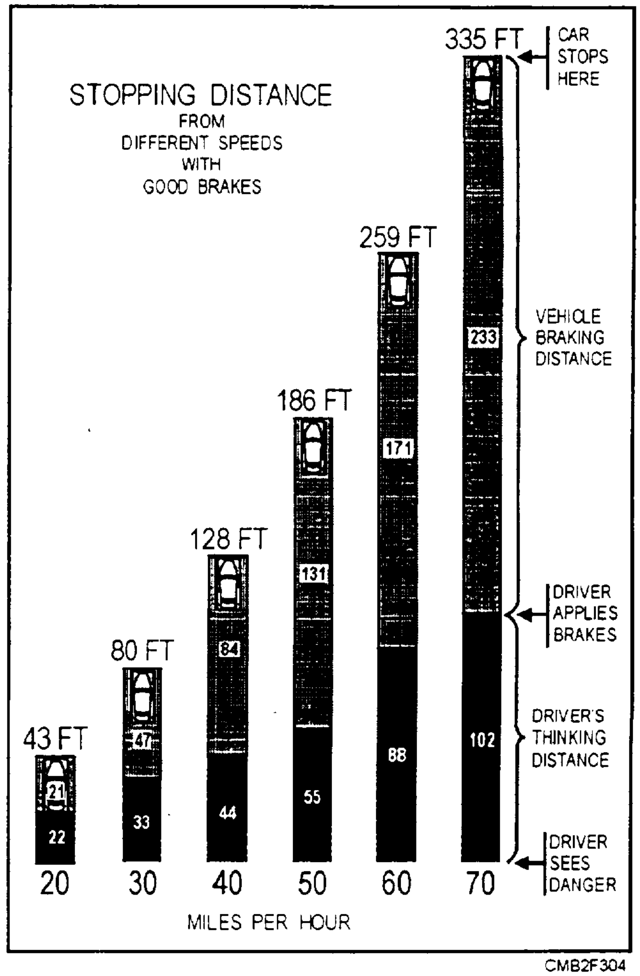


Figure 7-3.—Total vehicle stopping distance of an average vehicle.

Braking Temperature

Brakes are devices that convert the energy of a moving vehicle into heat whenever the brakes are applied. This heat must be absorbed and dissipated by the brake parts. Unless the heat is carried away as fast as it is produced, brake part temperatures will rise.

Since the heat generated by brake applications usually is greater that the rate of heat dissipation, high brake temperatures result. Ordinarily, the time interval between brake applications avoids a heat buildup. If, however, repeated panic stops are made, temperatures become high enough to damage the brake linings, brake drums. brake fluid, and, in some extreme cases, even tires have been set on fire.

Factors that tend to increase brake temperatures include the following:

- Load on the vehicle
- Operator abuse
- Speed of the vehicle
- Maladjustment of brakes
- Incorrect installation of brake parts
- Unbalanced braking

If road speeds are increased and/or more weight is placed in the vehicle, brake temperatures increase. In fact, under extreme conditions of unbalanced brakes on a heavy truck making an emergency stop from high speed, enough heat is generated to melt a cube of iron weighing 11.2 pounds.

Braking Ratio

Braking ratio refers to the comparison of front-wheel to rear-wheel braking effort. When a vehicle stops, its weight tends to transfer to the front wheels. The front tires are pressed against the road with greater force. The rear tires lose some of their grip on the road. As a result, the front wheels do more of the braking than the rear.

For this reason, many vehicles have disc brakes on the front and drum brakes on the rear. Disc brakes are capable of producing more stopping effort than drum brakes. If drum brakes are used on both the front and rear wheels, the front shoe linings and drums typically have a larger surface area.

Typically, front-wheel brakes handle 60 to 70 percent of the braking power. Rear wheels handle 30 to 40 percent of the braking. Front-wheel drive vehicles, having even more weight on the front wheels, have even a higher braking ratio at the front wheels.

HYDRAULIC SYSTEM

The hydraulic system applies the brakes at all four wheels with equalized pressure. It is pedal operated. The system consists of the master cylinder, the wheel cylinder, the brake lines and hoses, and the brake fluid.

Master Cylinder

The master cylinder is the primary unit in the brake system that converts the force of the operator's foot into fluid pressure to operate the wheel cylinders. It is normally mounted to the firewall, which allows for easy inspection and service, and is less prone to dirt and water. The master cylinder has four basic functions that are as follows:

- It develops pressure, causing the wheel cylinder pistons to move towards the drum or rotor.
- After all of the shoes or pads produce sufficient friction, the master cylinder assists in equalizing the pressure required for braking.
- It keeps the system full of fluid as the brake linings wear.
- It can maintain a slight pressure to keep contaminants (air and water) from entering the system.

In its simplest form, a master cylinder consists of a housing, a reservoir, a piston, a rubber cup, a return spring, a rubber boot, and a residual pressure check valve (fig. 7-4). There are two ports (inlet port and compensating port) drilled between the cylinder and reservoir. The description of the components of a master cylinder is as follows:

- The master cylinder housing is an aluminum or iron casting having either an integral or detachable reservoir. A cylinder is machined in the housing of the master cylinder. The spring, the cups, and the metal piston move within this cylinder.
- The piston is a long spoonlike member with a rubber secondary cup seal at the outer end and a rubber primary cup at the inner end, which are used to pressurize the brake system. The primary cup is held against the end of the piston by the return spring. A steel stop disc, held in the outer end of the cylinder by a retainer spring, acts as a piston stop.

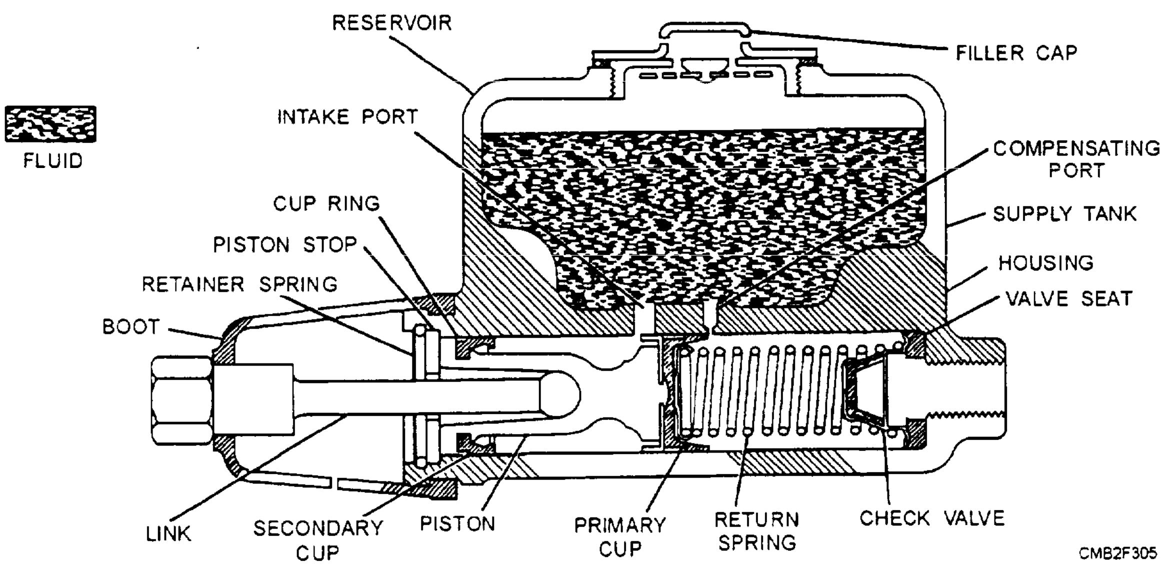


Figure 7-4.—Cutaway view of a single master cylinder.

A rubber boot prevents dust, dirt, and moisture from entering the back of the master cylinder. The boot fits over the master cylinder housing and the brake pedal pushrod.

- The reservoir carries a sufficient reserve of fluid to allow for expansion and contraction of brake fluid and brake lining wear. The reservoir is filled at the top and is well sealed by a removable filler cap containing a vent. Integral reservoirs are made of the same material as the cylinder. whereas detachable reservoirs are made of plastic.

- The intake port or vent allows fluid to enter the rear of the cylinder, as the piston moves forward. Fluid flows out of the reservoir, through the intake port, and into the area behind the piston and cup.

- The compensating port releases extra pressure when the piston returns to the released position. Fluid can flow back into the reservoir through the compensating port. The action of both ports keeps the system full of fluid.

- The residual pressure check valve maintains residual fluid pressure of approximately 10 psi. This pressure prevents fluid from seeping past the cups in the wheel cylinders and also prevents air from entering the hydraulic passages when the brakes are released.

Older vehicles used single piston, single reservoir master cylinders that were dangerous. If a fluid leak developed (cracked brake hose, seal damage, or line rupture). a sudden loss of braking ability occurred. Modern vehicles use dual master cylinders. These master cylinders provide an additional safety feature in that should one portion of the brake system fail. the other system will allow the vehicle to maintain some braking ability.

The dual master cylinder (fig. 7-5). also called a tandem master cylinder, has two separate hydraulic

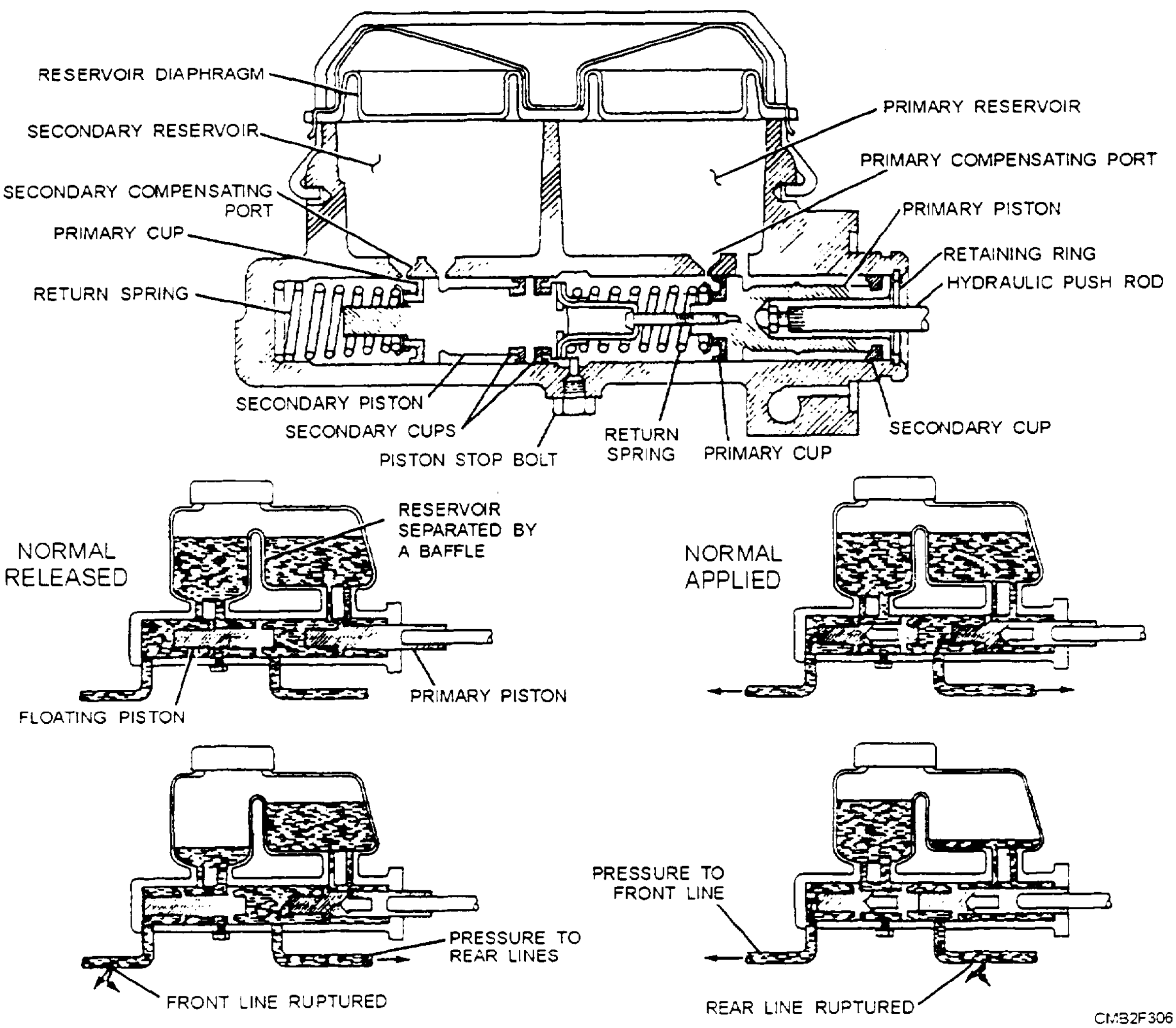


Figure 7-5.—Dual master cylinder.

pistons and two fluid reservoirs. In the dual master cylinder, the rear piston assembly is termed the *primary piston* and the front piston is termed the *secondary piston.*

In some dual master cylinders, the individual systems are designed where one master cylinder piston operates the front brake assemblies and the other operates the rear brake assemblies. This is knownI as a longitudinally split system (fig. 7-6). A system that has each master cylinder piston operating the brake assembly on opposite corners of the vehicle is known a diagonally split system (fig. 7-6). In either system, if there is a leak, the other master cylinder system can still provide braking action on two wheels.

When the systems are intact (no leaks), the pistons produce and supply pressure to all four of the wheel cylinders. However, if there is a pressure loss in the primary circuit of the brake system (rear section of the master cylinder), the primary piston slides forward and pushes on the secondary piston. As shown in figure 7-5, this action forces the secondary piston forward mechanically, building pressure in two of the wheel cylinder assemblies. Should the secondary circuit fail, braking for the other two wheels would still be

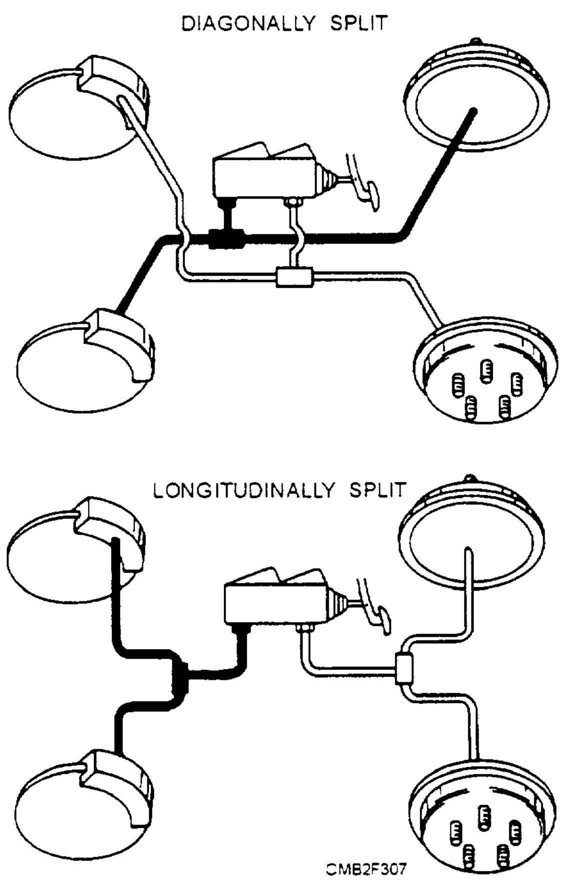


Figure 7-6.—Dual master cylinder braking systems.

available. The secondary piston slides completely forward in the cylinder, as shown in figure 7-5. Then the primary piston provides hydraulic pressure to the other two brake assemblies. It is very unlikely that both systems will fail at the same time.

When performing maintenance on a dual master cylinder, you may notice that the front reservoir is larger than the rear. This is a longitudinally split system. The larger reservoir is for disc brakes. The larger reservoir is necessary because as the disc pads wear, they move outward creating a larger cavity in the caliper cylinder and fluid moves from the master cylinder to fill the additional area. To allow this action to occur, the front reservoir of a longitudinally split system has no residual check valve. However, with a diagonally split system both reservoirs are the same size and the residual check valve for the rear brakes are located in the tees that split the system front to rear.

Wheel Cylinder

A wheel cylinder (fig. 7-7) changes hydraulic pressure into mechanical force that pushes the brake shoes against the drums. Other than the standard wheel cylinder, there are two other types that you may come in contact with—the stepped wheel cylinder and the single-piston wheel cylinder.

- The stepped wheel cylinder (fig. 7-7) is used to compensate for a faster rate of wear on the front shoe than on the rear shoe because of the self-energizing action of the brakes. This condition requires a stepped wheel cylinder with two bore sizes.

- The single-piston wheel cylinder (fig. 7-7) is used when it is desired that both brake shoes be independently self-energizing, especially on the front wheels. With this design it is necessary to have two wheel cylinders, one for each shoe. Each cylinder has a single piston and is mounted on the opposite side of the brake backing plate from the other cylinder. Such an arrangement is shown in figure 7-8.

NOTE

For further information on wheel cylinders, refer to "Drum Brake Assemblies" in this chapter.

Brake Lines and Hoses

Brake lines and hoses transmit fluid under pressure from the master cylinder to the wheel cylinders. The brake lines are made of double-wall steel tubing with double-lap flares on their ends. Rubber brake hoses are

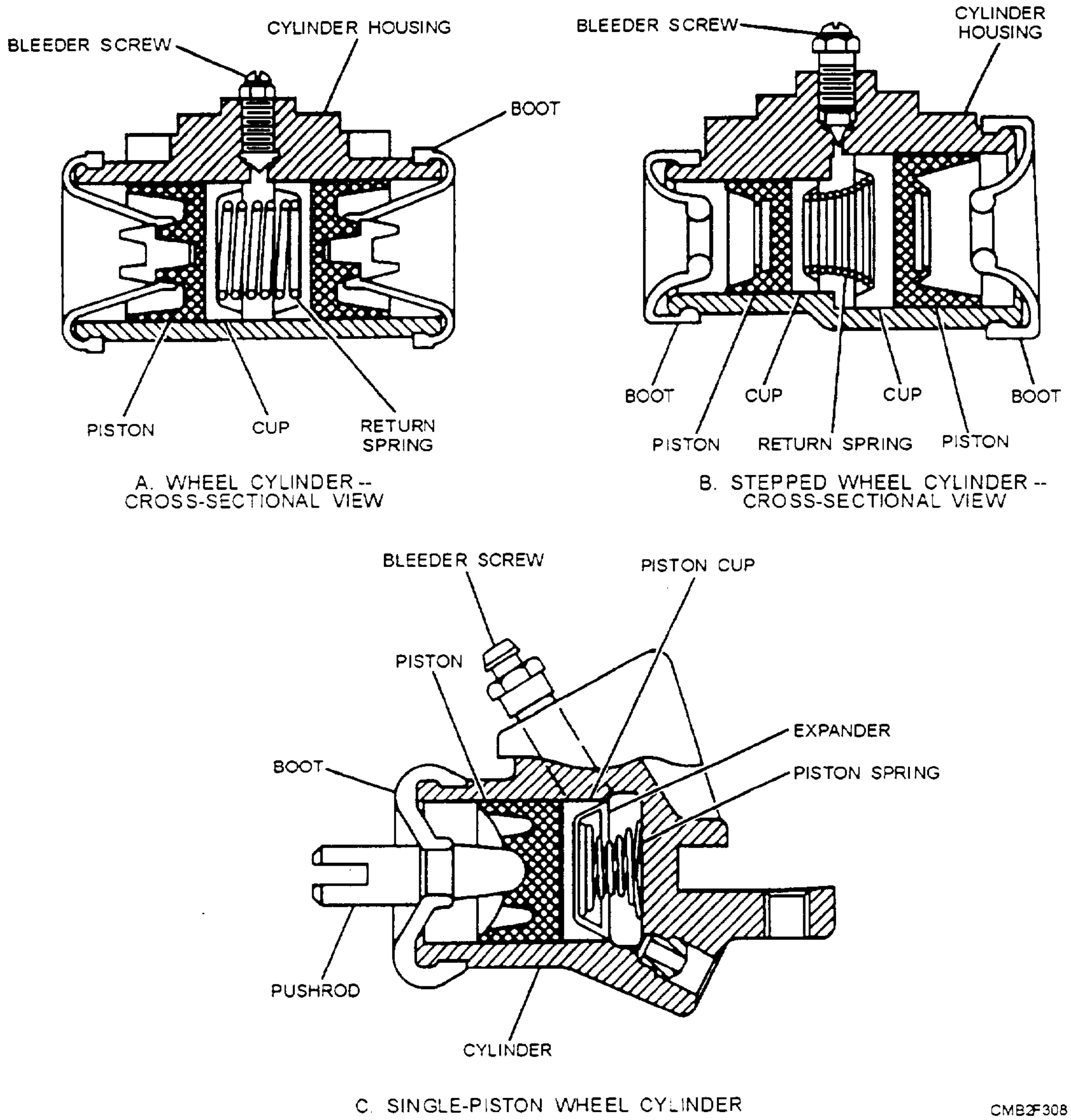


Figure 7-7.—Wheel cylinder configurations.

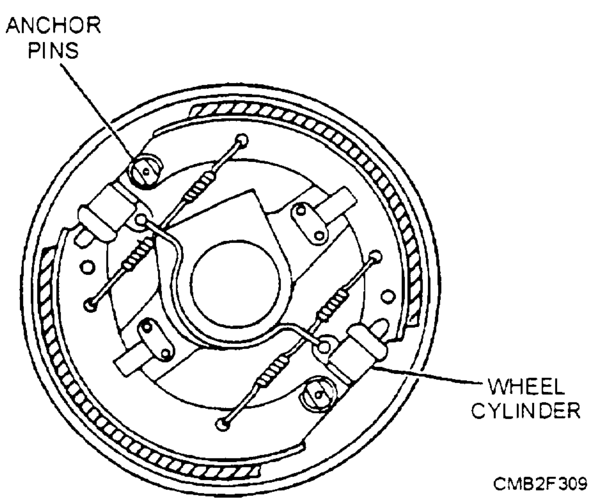


Figure 7-8.—Double-anchor, double-wheel cylinder configuration.

used where a flexing action is required. For example, a brake hose is used between the frame and the front-wheel cylinders or disc brake calipers. This design allows the wheels to move up and down, as well as side to side without damaging the brake line. Figure 7-9 shows the details of how brake lines and brake hoses fit together.

A junction block is used where a single brake line must feed two wheel cylindersorcalipers. It is a simply a hollow fittingwith one inlet and two or more outlets.

Mounting brackets and clips are used to secure brake lines and hoses to the unibody or frame of the vehicle. The mounting brackets help hold the assemblies secure and reduce the vibration which causes metal fatigue, thereby preventing line breakage.

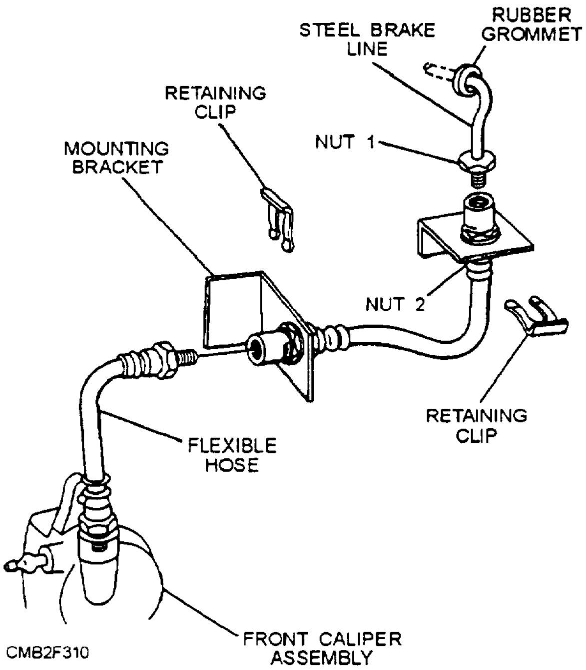


Figure 7-9.—Brake lines and hoses.

Steel lines seldom need replacing except in areas where they rust from exposure to salt air or constant high humidity. Flexible hoses should be inspected at regular maintenance periods for any signs of cracking or abrasion. Should the outer protective covering be cracked or badly abraded, it should be replaced.

Brake Fluid

Brake fluid is a specially blended hydraulic fluid that transfers pressure to the wheel cylinders or calipers. Brake fluid is one of the most important components of a brake system because it ties all of the other components into a functioning unit.

Vehicle manufacturers recommend brake fluid that meets or exceeds SAE (Society of Automotive Engineers) and DOT (Department of Transportation) specifications.

Brake fluid must have the following characteristics:

- Low freezing point (not freeze during cold weather)
- Water tolerance (absorb moisture that collects in the system)
- Lubricate (reduce wear of pistons and cups)
- Noncorrosive (not attack metal or rubber brake system components)
- Maintain correct viscosity (free flowing at all temperatures)
- High boiling point (remains liquid at the highest system operating temperature)

Standard brake fluid (DOT 3) is composed chiefly of equal parts of alcohol and castor oil. This combination of fluids works well under normal conditions but it easily boils and becomes a vapor under heavy-duty applications. Standard fluid also tends to separate when exposed to low temperatures. The increasing requirements of brake fluid led to the development of silicone brake fluid.

After many years of research and development, a brake fluid that was acceptable under extreme operating conditions was developed. This fluid achieved low water pickup and good corrosion protection. The fluid also provides good lubrication qualities and rubber compatibility. Silicone brake fluid has been used in most military vehicles since the end of 1982.

DRUM BRAKES

There are many types of brake system designs in use on modern vehicles. Regardless of the design, all systems require the use of rotating and nonrotating units. Each of these units houses one of the braking surfaces, which, when forced together, produce the friction for braking action. The rotating unit on many motor vehicle wheel brakes consists of a drum that is secured to and driven by the wheel. The nonrotating unit consists of the brake shoes and linkage required to applying the shoes to the drum.

Drum Brake Assemblies

Drum brakes have a large drum that surrounds the brake shoes and hydraulic wheel cylinder. Drum brake assemblies consist of a backing plate, wheel cylinder, brake shoes and linings, retracting springs, hold-down springs, brake drum, and adjusting mechanism.

BACKING PLATE.—The backing plate holds the brake shoes, springs (retracting and hold-down), wheel cylinder, and other associated parts inside the brake drum. It also assists in keeping road dirt and water out of the brakes. The backing plate bolts to the axle housing or spindle.

WHEEL CYLINDER.—The wheel cylinder assembly uses master cylinder pressure to force the brake shoes out against the brake drum. It is normally bolted to the top of the backing plate. The wheel cylinder consists of a cylinder or housing, expander spring, rubber cups, pistons, dust boots, and bleeder screw (fig. 7-10).

- The wheel cylinder housing encloses all the other parts of the assembly. It has a precision cylinder in it for the pistons, cups, and spring.

- The expander spring assists in holding the rubber cups against the pistons when the assembly is NOT pressurized. Sometimes the end of the springs has metal expanders (cup expanders) that help to press the outer edges of the cups against the wall of the wheel cylinder.

- The wheel cylinder cups are special rubber seals that keeps fluid from leaking past the pistons. They fit in the cylinder and against the pistons.

- The wheel cylinder pistons transfer force out of the wheel cylinder. These metal or plastic plungers act on pushrods that are connected to or directly on the brake shoes.

- The dust boots keep road dirt and water from entering the cylinder. They snap into grooves that are cast on the outside of the housing.

- The bleeder screw provides a means of removing air from the brake system. It threads into a hole in the back of the wheel cylinder. When the screw is loosened, hydraulic pressure is used to force air and fluid out of the system.

BRAKE SHOES.—Brake shoes are used to support, strengthen, and move the brake lining. Because the brake lining material is soft and brittle, it is necessary to add a supportive foundation to the lining so it will not collapse and break during use. The brake shoes also serve to attach the brake lining to a stationary unit. usually the backing plate. so braking action can be accomplished.

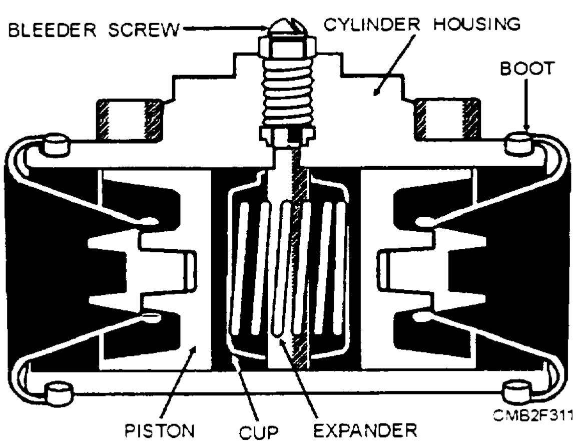


Figure 7-10.—Cross section of a wheel cylinder.

Brake shoes are made of malleable iron, cast steel, drop forged steel, pressed steel, or cast aluminum. Pressed steel is the most common because it is cheaper to produce in large quantities. Steel shoes expand at about the same rate as the drum when heat is generated by braking application, thereby maintaining the correct clearance between the brake drum and brake shoe under most conditions.

Automotive brake shoes consist of a primary and secondary shoe. The primary brake shoe is the front shoe and normally has a slightly shorter lining than the secondary shoe. The secondary shoe is the rear shoe and has the largest lining surface area.

Variation in brake design and operating conditions makes it necessary to have different types of brake linings. Brake linings come in woven and molded form (fig. 7-11).

The molded form is currently used on modern vehicles. Molded brake lining is made of dense, compact, asbestos fibers, sometimes impregnated with fine copper wire, and cut into sizes to match the brake shoe. Depending on how much metal fiber is used in their construction determines how they are classified, either as nonmetallic, semimetallic, and metallic linings.

- Nonmetallic linings contain very few metal fibers. This type of lining is used on many vehicles because of its quiet operation and good heat transfer qualities. Because of the lack of metal particles, the nonmetallic linings wear well with brake drums and do not tend to wear the drum excessively.

- Semimetallic linings have some metal particles in their composition. They also have good wearing properties and are quiet during application.

- Metallic linings have a high degree of metal fiber in their construction and are generally characterized by small pads bonded or welded to the brake shoe. The pads may have a small space between them to aid in cooling. The metallic linings operate at high temperatures and may require the use of special high-temperature brake parts. Metallic brake linings are generally used for heavy-duty brake application where large loads must be stopped or brakes are applied often.

Brake lining is riveted or bonded to the face of the brake shoe. Semitubular brass rivets are used to attach the lining to the shoe. Brass rivets are chosen over other types because brass does not score the brake drums excessively if the lining should be neglected and worn past the point of replacement.

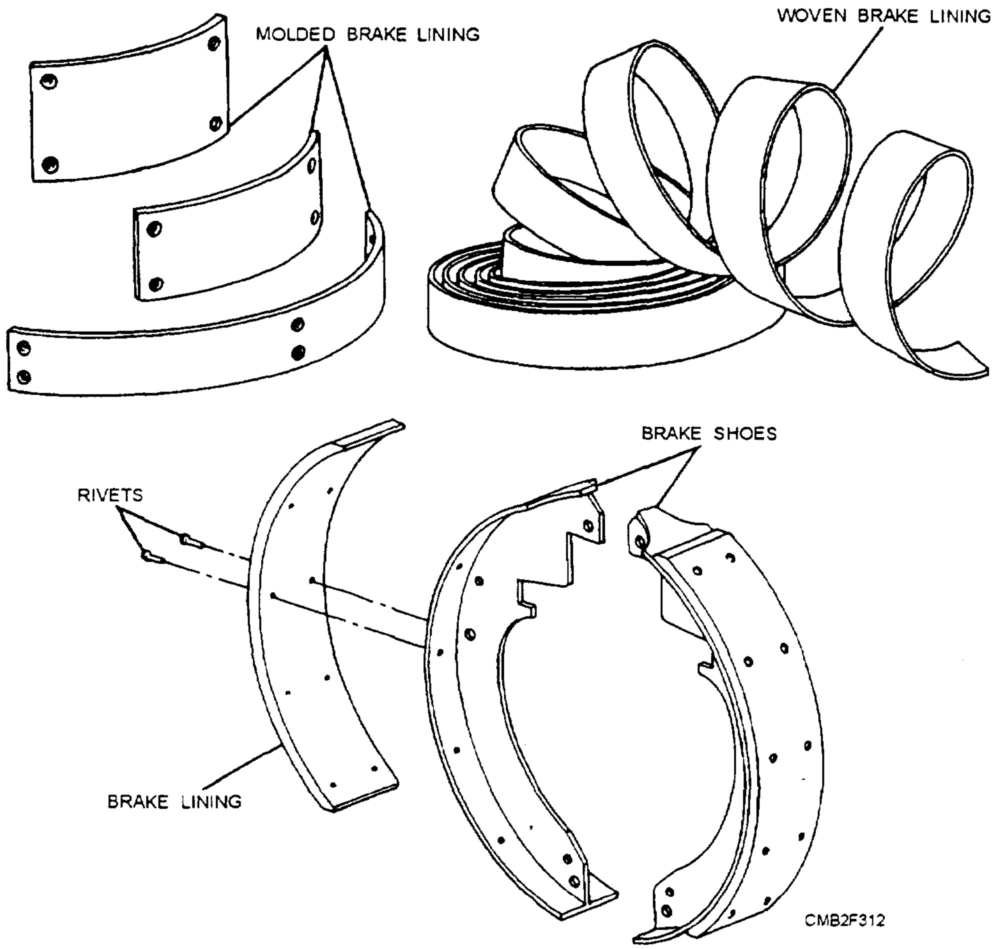


Figure 7-11.—Brake shoes and brake lining.

The lining may also be bonded directly to the brake shoe. In this process, a special bonding agent (glue) is used to adhere the lining to the brake shoe. After application, the shoe is baked at a predetermined temperature to ensure proper setting of the bonding agent.

BRAKE SPRINGS.—The brake springs within the brake drum assembly are the retracting springs and the hold-down springs. The retracting springs pull the brake shoes away from the brake drum when the brake pedal is released. The springs apply pressure to the brake shoes which push the wheel cylinder pistons inward. The retracting springs fit in holes in the brake shoes and around the anchor pin at the top of the backing plate.

Hold-down springs hold the brake shoes against the backing plate when the brakes are in a released position. A hold-down pin fits through the back of the backing plate, the spring placed over the pin, and a metal cup locks onto the pins to secure the hold-down springs to the shoes. Other springs are used on the adjusting mechanism. Brake springs are high quality, capable of withstanding the high temperatures encountered inside the brake drum.

BRAKE DRUMS.—The brake drum is attached to the wheel and provides the rotating surface for the brake linings to rub against to achieve braking action. The brake drum is grooved to mate with a lip on the backing plate that provides the rotating seal to keep water and dirt from entering the brake assembly.

Brake drums may be made of pressed steel, cast iron, a combination of the two metals, or aluminum. Cast-iron drums dissipate the heat generated by friction faster than steel drums and have a higher coefficient of friction with any particular brake lining. However, cast-iron drums of sufficient strength are heavier than steel drums. To provide lightweight and sufficient strength, use CENTRIFUSE brake drums (fig. 7-12). These drums are made of steel with a cast-iron liner for the braking surface. A solid cast-iron drum of the same total thickness as the centrifuse drum would be too weak, while one of sufficient strength would be too heavy for the average vehicle.

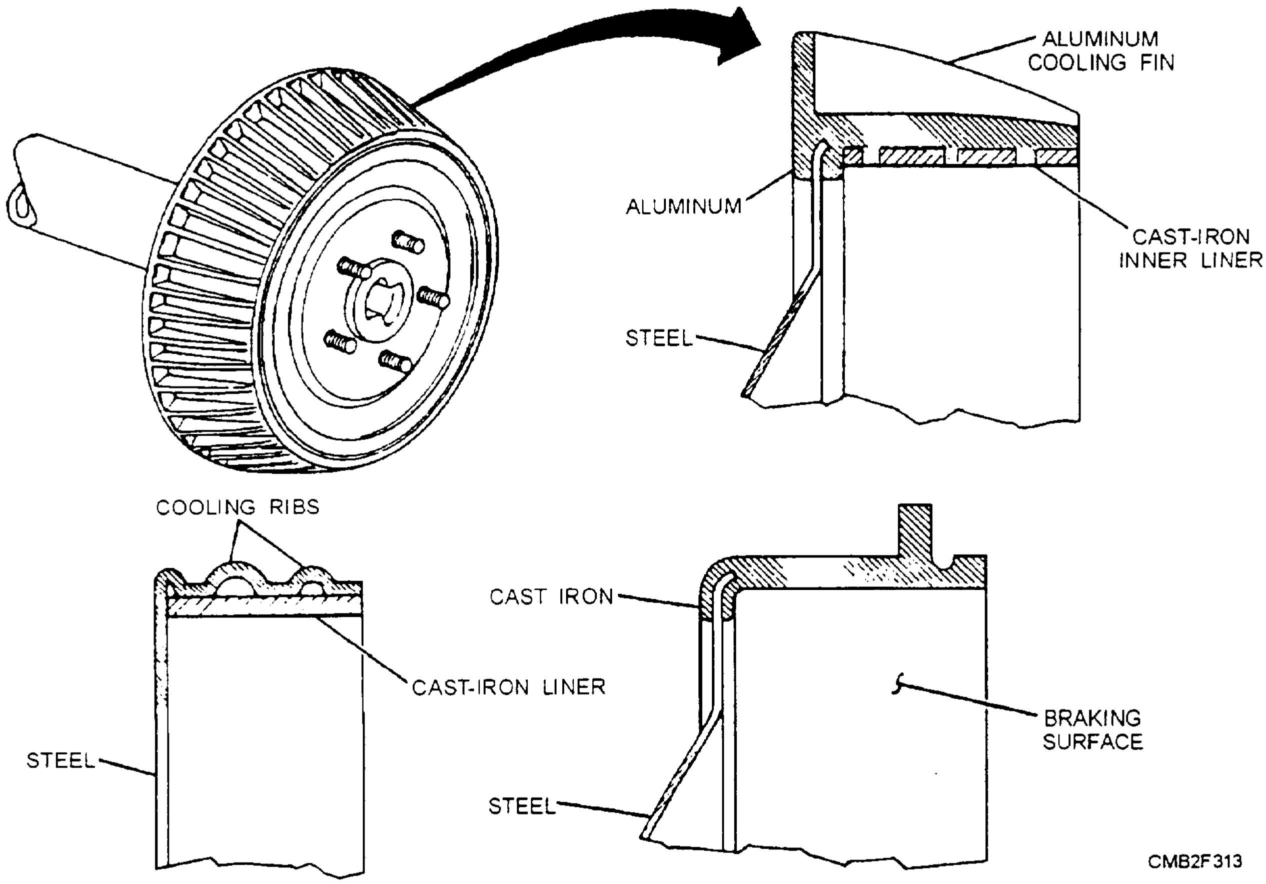


Figure 7-12.—Brake drum construction.

Aluminum brake drums are constructed similar to the centrifuse drums. They consist of an aluminum casting with a cast-iron liner for a braking surface. This design allows heat to be transferred to the surrounding atmosphere more readily and also reduces weight.

Cooling fins or ribs are added to most brake drums. The fins or ribs increase the surface area of the outside portion of the brake drum, allowing the heat to be transferred to the atmosphere more readily, which keeps the drum cooler and helps minimize brake fade.

For good braking action, the brake drum should be perfectly round and have a uniform surface. Brake drums become out-of-round from pressure exerted by brake shoes and from heat developed by application of the brakes. The brake drum surface becomes scored when it is worn by braking action. When the braking surface is scored or the brake drum is out-of-round, it may be necessary to machine the brake drum until it is smooth and true again. Care must be taken not to exceed the maximum allowable diameter according to the manufacturer's specification. Each drum is stamped with the maximum diameter information and. if exceeded, it should be discarded and replaced with a new one.

BRAKE SHOE ADJUSTERS.—Brake shoe adjusters maintain correct drum-to-lining clearance, as the brake linings wear. Automatic brake shoe adjusters normally function when the brakes are applied with the vehicle moving in reverse. If there is too much lining clearance, the brake shoes move outward and rotate with the drum enough to operate the adjusting lever. This lengthens the adjusting mechanism, and the linings are moved closer to the brake drum, thereby maintaining the correct lining-to-drum clearance.

Many vehicles use a star wheel (screw) type brake shoe adjusting mechanism. This type consists of a star wheel (adjusting screw assembly), adjuster lever, adjuster spring, and an adjusting mechanism. The adjustment system may grouped as follows (fig. 7-13):

- Cable type—The cable type self-adjusting system (fig. 7-13) uses a braided steel cable and the expanding action of both brake shoes to accomplish the self-adjusting action in forward and reverse directions. A one-piece cable is attached to the adjusting lever and passes through a cable guide on the primary shoe. The

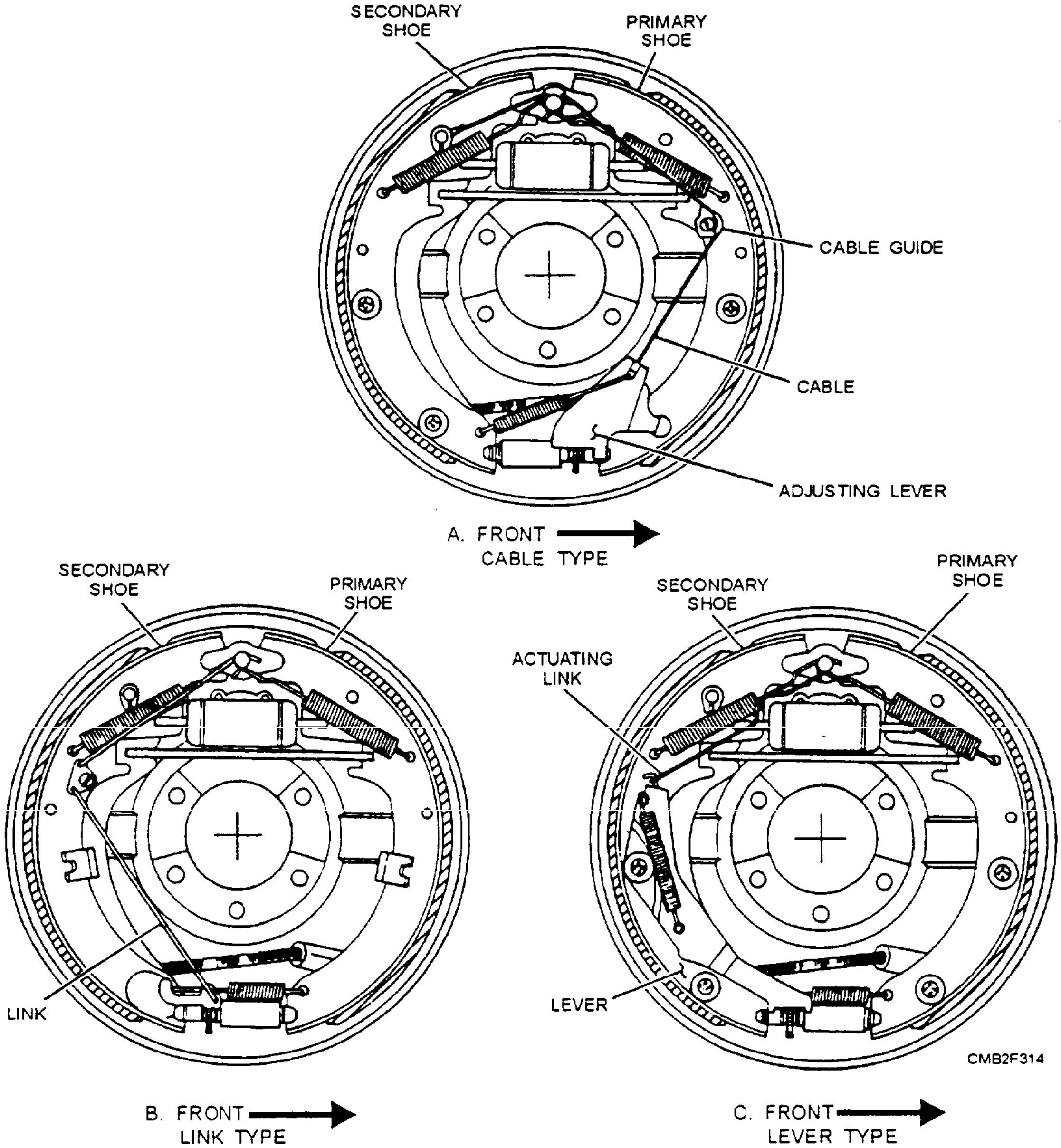


Figure 7-13.—Self-adjusting mechanisms.

cable then is passed up and over the anchor and attached to the secondary shoe. Operation is as follows:

1. Brakes are applied and the shoes expand and contact the drum.

2. The primary shoe self-energizes, and, through servo action, applies the secondary shoe.

3. The heel of the secondary shoe is lodged against the anchor pin.

4. The movement of the primary shoe tightens the cable by shifting the cable guide outward and in the direction of rotation.

5. The cable then moves the adjusting lever upward. If enough shoe-to-drum clearance is available, the adjusting lever will engage the next tooth on the star wheel. The brake shoes retract and the cable slackens, as the brakes are released. The return spring then helps force the adjusting lever downward, rotating the star wheel, which expands the brake shoes. In the reverse direction, the toe of the primary shoe is forced against the anchor, and the secondary shoe moves around to tighten the adjusting cable. The adjusting process is then completed.

- Link type—The link type self-adjusting system (fig. 7-13) uses solid linkage rods to connect the adjusting lever to the stationary anchor point. The two linkage rods, connected together by a bell crank that pivots on the secondary brake shoe, operate the adjuster. One rod attaches to the anchor point and the bell crank, while the other rod connects the bell crank and the adjusting lever. In this configuration. the self-adjuster works only in reverse direction. As the vehicle is backing up and the brakes are applied, the adjusting process is as follows:

1. The secondary, shoe moves away from the anchor because of the self-energizing action.

2. The pivot point of the bell crank is moved in the direction of rotation.

3. The lever moves up on the star wheel through the connection of the linkage. If enough clearance is available between the brake shoes and the drum, the lever will engage another tooth on the star wheel. As the brakes are released. the shoes retract and the return spring helps force the adjusting lever down, rotating the star wheel and expanding the adjusting screw to remove excess shoe-to-drum clearance.

- Lever type—The lever type self-adjusting system (fig. 7-13) is similar to the link type, in that it operates in reverse direction only. While the link type system uses linkage rods to perform the adjusting process, the lever type uses a stamped metal lever to engage the star wheel and actuating link to connect to the anchor pin. The adjusting process is the same as the link type system.

Brake Shoe Energization

The primary function of the brake drum assembly is to force the brake shoes against the rotating drum to provide the braking action. When the brake shoes are forced against the rotating drum. they are pulled away from their pivot point by friction. This movement, called self-energizing action (fig. 7-14), draws the shoes tighter against the drum.

As the brake actuating mechanism forces the brake shoes outward, the top of the brake shoe tends to stick or wedge to the rotating brake drum and rotates with it. This effect on brake shoes greatly reduces the amount of effort required to stop or slow down the vehicle.

With most drum brake designs, shoe energization is supplemented by servo action. When two brake shoes are linked together, as shown in figure 7-14, the application of the brakes will produce a self-energizing effect and also a servo effect. Servo action is a result of the primary (front) shoe attempting to rotate with the brake drum. Because of the fact that both shoes are linked together, the rotating force of the primary shoe applies the secondary, (rear) shoe.

In the forward position, the anchor point for both brake shoes is at the heel of the secondary, shoe. As the vehicle changes direction from forward to reverse, the toe of the primary shoe becomes the anchor point, and the direction of self-energization and servo action changes (fig. 7-14). The most popular brake drum configurations (fig. 7-15) are as follows:

- Single anchor, self-energizing servo action (fig. 7-15)—In this configuration both brake shoes are self-energizing in both forward and reverse directions. The brake shoes are self-centering and provide servo action during brake application. This system is provided with one anchor pin. which is rigidly mounted to the backing plate and is nonadjustable. Both forward and reverse torque is transmitted to the backing plate through the anchor pin. One wheel cylinder with dual pistons is used in this system.

- Single anchor, self-centering (fig. 7-15)—In this configuration only the primary brake shoe is self-energizing in the forward direction; therefore. it provides the majority of the brake force. This system is self-centering in that the lower brake shoe anchor does not fix the position of the brake shoes in relation to the drum. The shoes are allowed to move up and down as needed. Some systems provide eccentric cams for front and rear brake shoe adjustments. One wheel cylinder is provided in this system.

- Double anchor, single cylinder (fig. 7-15)—In this arrangement, each brake shoe is anchored at the bottom by rotating eccentric-shaped anchor pins. Only the primary shoe is self-energizing. and the system does not develop servo action. Spring clips are used in the middle of the shoe to hold the shoes against the backing plate. Brake shoes are adjusted manually by rotating the anchor pins. One wheel cylinder is provided in this arrangement.

- Double anchor. double cylinder (fig. 7-15)—In this system the brake shoes are provided with an anchor at each heel. The anchors are eccentric-shaped to allow for adjustment and centering. Each shoe has a single piston wheel cylinder mounted at the toe of the brake shoe. Which allows both shoes to be self-energizing in the forward direction only. Eccentrics mounted in the middle of the shoe also allow for brake adjustment.

Disadvantages of Drum Brakes

The drum brake assembly, although well suited for wheeled vehicles, has some disadvantages. One

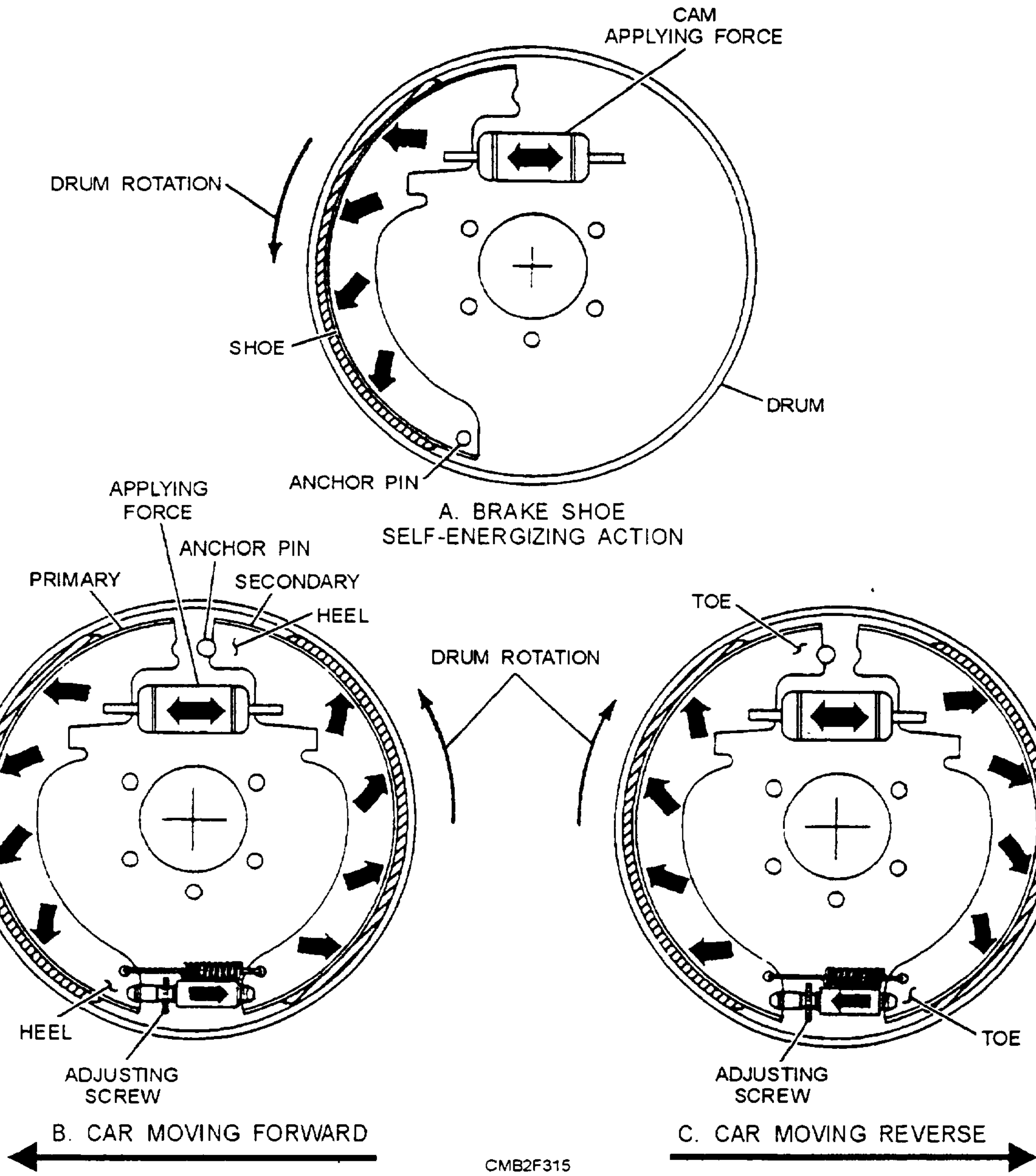


Figure 7-14.—Self-energizing and servo action.

problem that occurs during heavy braking is brake fade. During panic stops or repeated harsh stops, the brake linings and drum develop large amounts of heat that reduces the amount of friction between the brake shoe and drum. This reduction in friction greatly decreases the stopping ability of the vehicle, and, in most cases, additional pressure directed on the brake pedal would not increase the stopping performance of the vehicle.

The enclosed design of the brake drum assembly does not allow for cooling air to enter the assembly and therefore heat developed during braking must be dissipated through the brake drum and backing plate. As the brakes heat up due to repeated application, cooling air flowing past the drums and backing plates is limited. This condition causes the radius of the drum to increase more than the radius of the brake shoe. As a result, a change in pressure distribution between the linings and the drum occurs, which reduces the braking ability of a vehicle by up to 20 percent.

The enclosed design also does not allow for water to be expelled rapidly should the brake cavity become wet due to adverse weather conditions. The water reduces the frictional properties of the brake system and must be removed to restore braking ability. This is a very dangerous situation and drastically reduces the stopping ability of the vehicle until the system is dry.

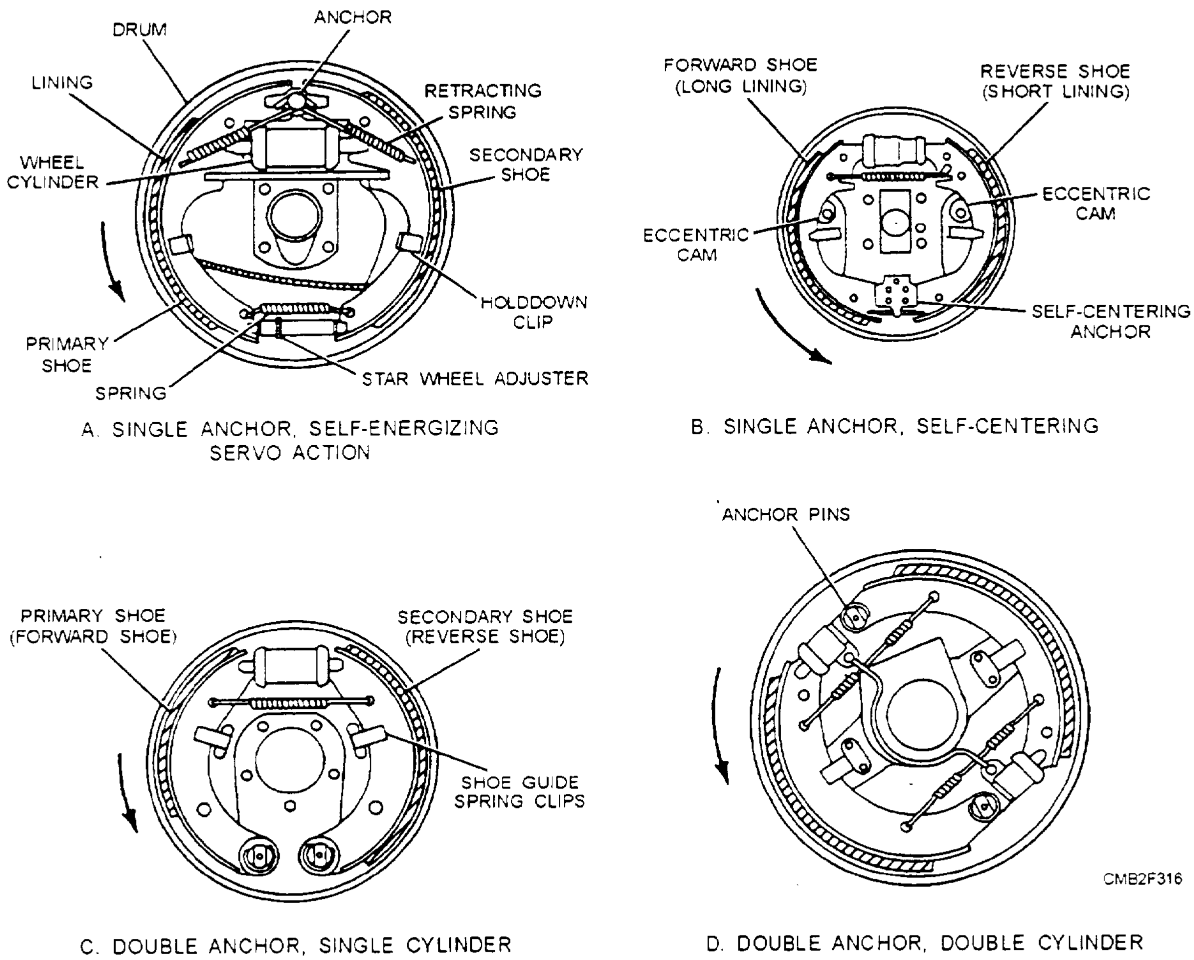


Figure 7-15.—Brake drum configurations.

The use of many clips and springs makes overhaul of the brake drum assembly very time-consuming. Because of the enclosed drum. asbestos dust is collected in the brake cavity and certain parts of the brake drum.

CAUTION

Asbestos can cause cancer. Grinding brake lining and cleaning of the brake assembly can cause small particles of asbestos to become airborne. Always wear personal protection equipment. Dispose of waste material and cleaning rags as hazardous waste. For more information. see OPNAVINST 4110.2, *Hazardous Material Control and Management.*

DISC BRAKES

With the demands for increased safety in the operation of automotive vehicles, many are now equipped with disc brakes. The major advantage of the disc brake is a great reduction in brake fade and the consequent marked reduction in the distance required to stop the vehicle.

Braking with disc brakes is accomplished by forcing friction pads against both sides of a rotating metal disc, or rotor. The rotor turns with the wheel of the vehicle and is straddled by the caliper assembly. When the brake pedal is depressed, hydraulic fluid forcesthe pistonsand friction linings (pads) against the machined surfaces of the rotor. The pinching action of the pads quickly creates friction and heat to slow down or stop the vehicle.

Disc brakes do not have servo or self-energizing action. Therefore, the applying force on the brake pedal must be very great in order to obtain a brake force comparable to that obtained with the conventional drum brake. Consequently, disc brakes are provided with a power or booster unit and a conventional master cylinder.

In many installations, disc brakes are used only on the front wheels and drum brakes are continued on the rear. However, you may on occasion find disc brakes used on all four wheels.

Disc Brake Assembly

Disc brakes are basically like the brakes on a ten-speed bicycle. The friction elements are shaped like pads and are squeezed inwards to clamp a rotating disc or wheel. A disc brake assembly consists of a caliper, brake pads, rotor, and related hardware (bolts, clips, and springs), as shown in figure 7-16.

BRAKE CALIPER.—The caliper is the nonrotating unit in the system and it may be mounted to the spindle or splash shield to provide support. The brake caliper assembly includes the caliper housing, the piston(s), the piston seal(s), the dust boot(s), the brake pads or shoes, and the bleeder screw.

The caliper is fitted with one or more pistons that are hydraulically actuated by the fluid pressure developed in the system. When the brake pedal is applied, brake fluid flows into the caliper cylinder. The piston is then forced outward by fluid pressure to apply the brake pads to the rotor.

The piston seal in the caliper cylinder prevents pressure leakage between the piston and cylinder. The piston seal also helps pull the piston back into the cylinder when the brakes are released. The elastic action of the seal acts as a spring to retract the piston and maintain a clearance of approximately 0.005 inch when the brakes are released.

The piston boot keeps road dirt and water off the caliper piston and wall of the cylinder. The boot and seal fit into grooves cut in the caliper cylinder and piston.

A bleeder screw allows air to be removed from the hydraulic system. It is threaded into the top or side of the caliper housing. When loosened, system pressure is used to force fluid and air out of the bleeder screw.

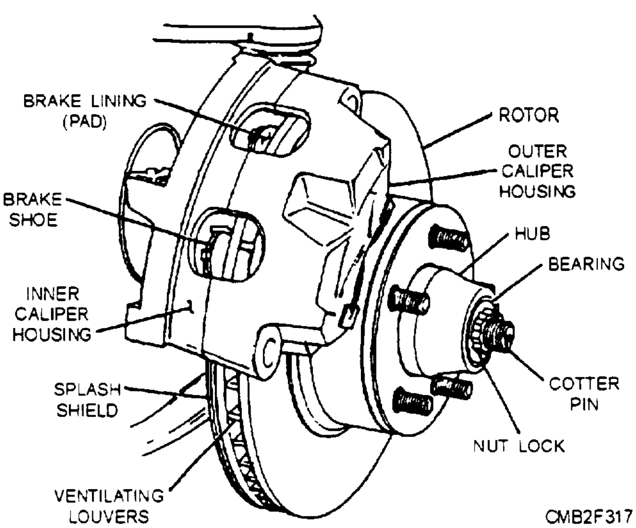


Figure 7-16.—Disc brake assembly.

DISC BRAKE PADS.—Disc brake pads consist of steel shoes to which the lining is riveted or bonded. Brake pad linings are made of either asbestos (asbestos fiber filled) or semimetallic (metal particle filled) friction material. Many new vehicles, especially those with front-wheel drive, use semimetallic linings. Semimetallic linings withstand higher operating temperatures without losing their frictional properties.

Antirattle clips are frequently used to keep the brake pads from vibrating and rattling. The clip snaps onto the brake pad to produce a force fit in the caliper. In some cases, an antirattle spring is used instead of a clip.

A pad wear indicator (a metal tab) informs the operator of worn brake pad linings. The wear indicator produces an audible high-pitch squeak or squeal, as it scrapes against the brake disc. This harsh noise is a result of the linings wearing to a point, allowing the indicator to rub against the brake disc, as the wheel turns.

BRAKE DISC.—Also called brake rotor, the brake disc uses friction from the brake pads to slow or stop the vehicle. Made of cast iron, the rotor may be an integral part of the wheel hub. However, on many front-wheel drive vehicles, the disc and hub are separate units.

The brake disc may be a ventilated rib or solid type. The ventilated rib disc is hollow that allows cooling air to circulate inside the disc.

Disc Brake Types

Disc brakes can be classified as floating, sliding, and fixed caliper types. Floating and sliding are the most common types. The fixed caliper may be found on older vehicles.

FLOATING CALIPER.—The floating caliper type disc brake (fig. 7-17) is designed to move laterally on its mount. This movement allows the caliper to maintain a centered position with respect to the rotor. This design also permits the braking force to be applied equally to both sides of the rotor. The floating caliper usually is a one-piece solid construction and uses a single piston to develop the braking force.

Operation of a floating caliper is as follows:

- Fluid under pressure enters the piston cavity and forces the piston outward. As this happens the brake pad contacts the rotor.

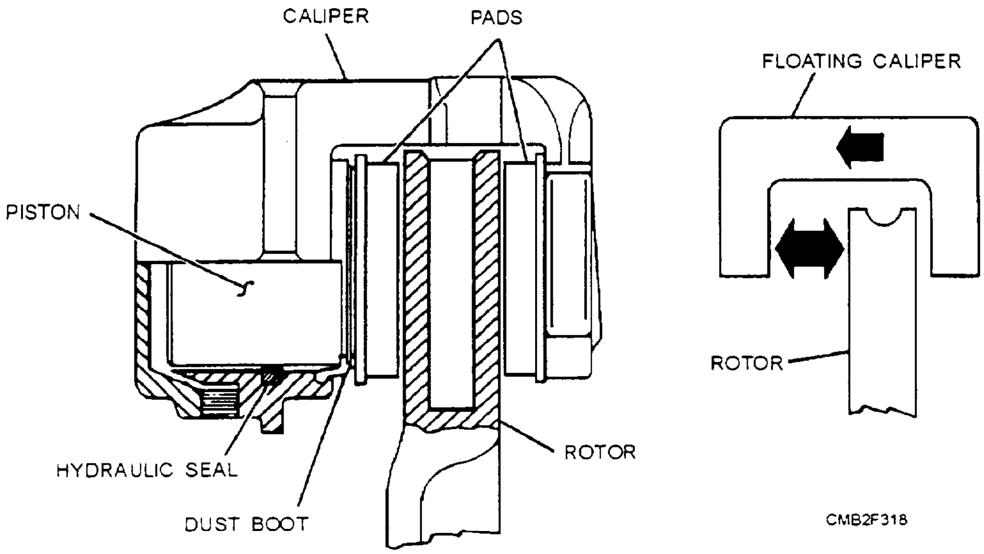


Figure 7-17.—Floating caliper.

- Additional pressure then forces the caliper assembly to move in the opposite direction of the piston, thereby forcing the brake pad on the opposite side to contact the rotor.
- As pressure is built up behind the piston, it forces the brake pads to tighten against the rotor. This action develops additional braking force.

SLIDING CALIPER TYPE.—The sliding caliper type disc brake (fig. 7-18) is mounted in a slot in the caliper adapter. It is a variation of the floating caliper, using a single piston and operating on the same principle, whereby the piston applies pressure to one brake pad and the movable caliper applies pressure to the other.

This design has two major sections—the sliding caliper and the caliper adapter (anchor plate). Each has two angular machined surfaces: this is where the sliding contacts come into play. The machined surfaces of the caliper housing slide on the mated

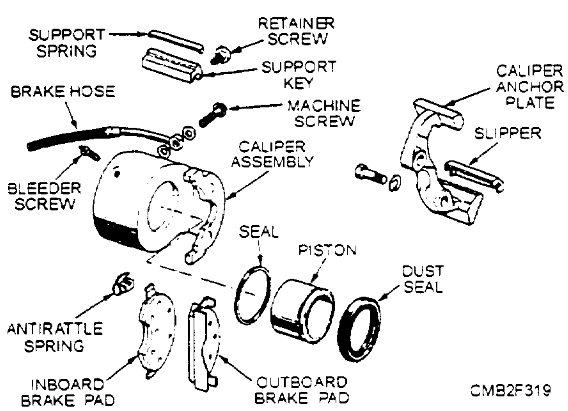


Figure 7-18.—Sliding caliper.

surfaces of the caliper adapter when the brakes are applied.

FIXED CALIPER.—The fixed caliper disc brake (fig. 7-19) is rigidly mounted to the spindle or splash shield. In this design, the caliper usually is made in two pieces and has two or more pistons in use.

The pistons accomplish the centering action of the fixed caliper, as they move in their bores. If the lining should wear unevenly on one side of the caliper, the piston would take up the excess clearance simply by moving further out of the bore.

As the brakes are applied, fluid pressure enters the caliper on one side and is routed to the other through an internal passage or by an external tube connected to the opposite half of the caliper. As pressure is increased, the pistons force the brake pads against the rotor evenly, therefore maintaining an equal amount of pressure on both sides of the rotor.

BRAKE SWITCHES AND CONTROL VALVES

There are several types of switches and control valves used in hydraulic brake systems. Switches are normally safety devices. and there are two types used—the stoplight switch and the braking warning light switch. Control valves regulate pressure within the braking system, and there are three types—the metering valve, the proportioning valve. and the combination valve.

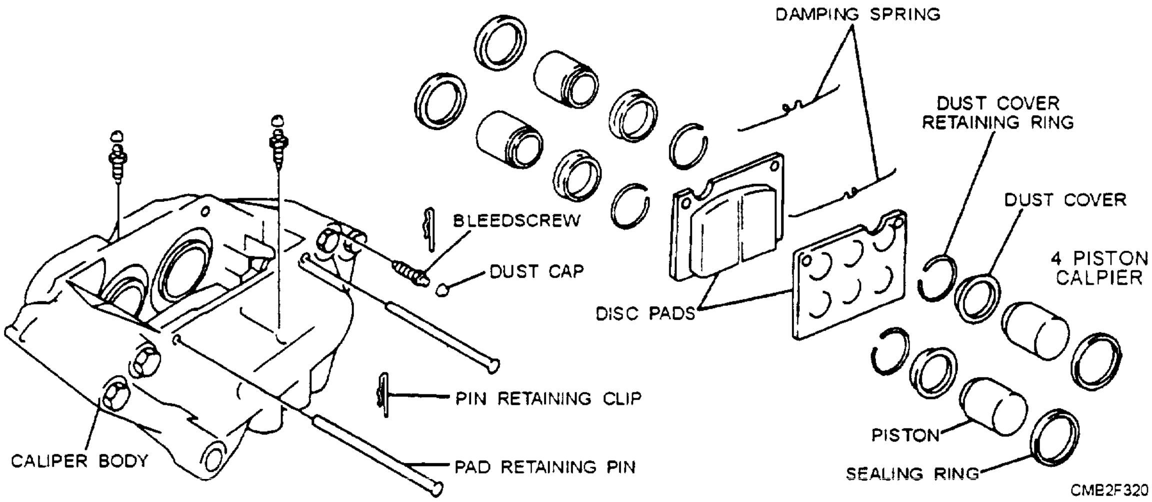


Figure 7-19.—Fixed multipiston caliper.

Stoplight Switch

The stoplight switch is a spring-loaded electrical switch that operates the rear brake lights of the vehicle. Most modern vehicles use a mechanical switch on the brake pedal mechanism. The switch is normally open, and when the brake pedal is depressed, the switch closes and turns on the brake lights.

On some older vehicles you may find hydraulically operated stoplight switches. In this system, brake pressure acts on a switch diaphragm, which closes the switch to turn on the brake lights.

NOTE

Brake light circuits are covered in chapter 2 of this TRAMAN.

Brake Warning Light Switch

The brake Learning light switch, also called the pressure differential valve, warns the operator of a pressure loss on one side of a dual brake system. If a leak develops in either the primary or secondary brake system. unequal pressure acts on each side of the warning light piston, moving the piston to one side thereby grounding the switch.

Metering Valve

The metering valve is designed to equalize braking action at each wheel during light brake applications. A metering valve is used on vehicles with front disc brakes and rear drum brakes and is located in the line to the disc brakes. The metering valve functions by preventing the disc brakes from applying until approximately 75 to 135 psi has built up in the system.

Proportioning Valve

The proportioning valve also equalizes braking action with front disc brakes and rear drum brakes. It is located in the brake line to the rear brakes. The function of the proportioning valve is to limit pressure to the rear brakes when high pressure is required to apply the front disc. This prevents rear wheel lockup and skidding during heavy brake applications.

Combination Valve

The combination valve (fig. 7-20) combines several valve functions into a single assembly. It functions as a—

- Metering valve—holds off front disc braking until the rear drum brakes make contact with the drums.
- Proportioning valve—improves front to rear brake balance at high deceleration by reducing rear brake pressure to delay rear wheel skid.
- Brake light warning switch (pressure differential valve)—lights a dash-warning lamp if either front or rear brake systems fail.

ANTILOCK BRAKE SYSTEM (ABS)

The antilock brake system (ABS) is used because it provides CONTROL. Skidding causes a high percentage ofvehicle accidents on the highway and the ABS (fig. 7-21), also known as a skid control brake system, uses wheel speed sensors, hydraulic valves, and the on-board computer to prevent or limit tire

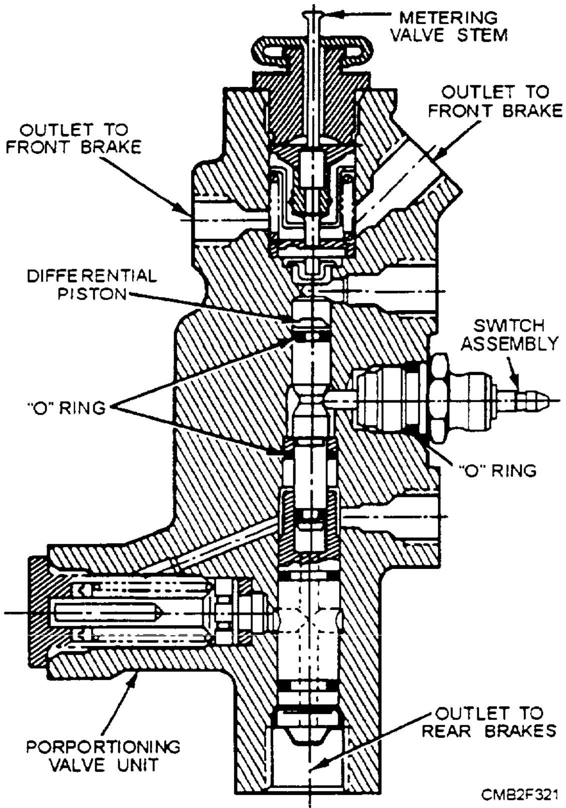


Figure 7-20.—Combination valve.

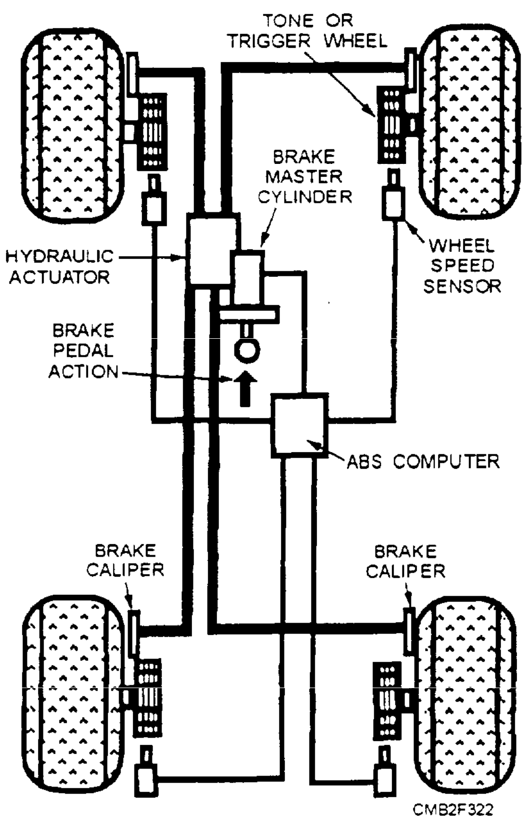


Figure 7-21.—Basic antilock brake system.

lockup. The basic parts of an antilock brake system are as follows:

- ABS COMPUTER—a microcomputer that functions as the "brain" of the ABS system. The computer receives wheel-end performance data from each wheel speed sensor. When the wheels try to lock, the computer delivers commands to operate the hydraulic actuator to control brake pressure. The computer also monitors brake pedal position, detects and prevents potential wheel lockup conditions while maintaining optimum braking performance, stores and displays diagnostic codes, and alerts the operator of a system malfunction by turning on the system lamp.

- HYDRAULIC ACTUATOR—an electric-hydraulic valve that modulates the amount of braking pressure (psi) going to a specific wheel circuit.

- TRIGGER WHEELS—a toothed ring that is mounted on each wheel spindle or hub.

- WHEEL SPEED SENSORS—a magnetic sensor that uses trigger wheel rotation to produce a weak alternating current.

The operation of an antilock brake system is as follows:

- A wheel speed sensor is mounted at each wheel to measure trigger wheel rotation in rpms. The sensor sends alternating or pulsing current signals to the ABS computer.

- If one or more wheels decelerate at a rate above an acceptable perimeter, the sensor signals reduce frequency and the ABS computer activates the hydraulic actuators. The actuator then cycles ON and OFF as much as 15 times per second to reduce braking pressure to the brake assembly for that wheel. This action prevents the vehicle from skidding.

- The ABS computer will continue to modulate brake pressure until the operator releases the brake pedal, the wheel speed sensor no longer detects a lockup condition, or the vehicle stops.

Tips on using antilock braking systems are as follows:

- Always "brake and steer" when using antilock brakes. Most operators were taught to pump the brakes and turn hard to the right or left to compensate for skidding. With antilock brakes, all a operator needs to do is "brake and steer." With four-wheel antilock brakes, push the brake pedal hard while steering normally and keep your foot firmly on the brake pedal until the vehicle comes to a complete stop. Operators with rear-wheel antilock brakes should step firmly with care. and if they feel the wheel locking, they should release some pressure.

- Expect noise and vibration in the brake pedal when antitock brakes are in use. The mechanical noise or pulsation of antilock brakes when in use might catch an operator by surprise; however, these sensations tell you that the system is working.

- Remember that you can steer while braking with a four-wheel antilock brake system. Steering is not always instinctive in an emergency. But steer out of danger while braking with antilock brakes. And remember that while you have steering capability, your vehicle may not turn as quickly white braking on a slippery road, as it would on dry pavement.

- The rear-wheel antitock brakes typically found on light-duty trucks provide vehicle stability but do not give you the steering capability of four-wheel antilock brakes.

- Anti lock brakes can often stop more quickly than conventional brakes but they can't overcome the law of physics. Antilock brakes function well on wet-paved surfaces and icy or packed snow-covered roads. Stopping times will be longer on gravel or fresh snow, although operators won't experience the dangerous lockup of wheels usually associated with conventional brakes.

- Drive safely because antilock brakes are only as good as the operators using them. Antilock brakes cannot compensate for driving too fast, too aggressively or failing to maintain a safe distance between vehicles. They cannot guarantee recovery from a spin or skid before braking. Also avoid extreme steering maneuvers while antilock brakes are engaged.

- Your antilock braking system instrument panel tight will go on for a few seconds after starting the ignition. The tight goes on so the system can conduct the normal system test. If the tight does not go on during ignition or if the tight goes on during normal driving, this means that a problem has been detected and the antilock braking system has been shut off. Conventional braking will continue. Consult the manufacturer's service manual if this problem occurs.

Since exact antitock brake systems vary, consult the vehicle manufacturer's service and repair manuals for more details of system operation.

POWER BRAKES

Power brakes systems are designed to reduce the effort required to depress the brake pedal when stopping or holding a vehicle stationary. The booster is located between the brake pedal linkage and the master cylinder.

Most power brake systems use the difference between intake manifold vacuum and atmospheric pressure to develop the additional force required to apply the brakes. When the operator depresses the brake pedal, the power booster increases the amount of pressure applied to the piston within the master cylinder without the operator having to greatly increase brake pedal pressure.

When a vehicle is powered by a diesel engine, the absence of intake manifold vacuum requires the use of an auxiliary vacuum pump. This pump may be driven by the engine or by an electric motor.

Vacuum Boosters

On many modern vehicles, vacuum boosters are used with the hydraulic brake system to provide easier brake application. In a hydraulic brake system there are limitations as to the size of the master cylinder and wheel cylinders that can be practically employed. Furthermore, the physical strength of the operator limits the amount of force that can be applied, unless the brakes are self-energizing. These factors restrict the brake shoe to brake drum pressure obtainable. Vacuum boosters increase braking force.

A vacuum booster consists of a round enclosed housing and a diaphragm. The power brake vacuum booster uses engine vacuum (or vacuum pump action on a diesel engine) to apply the hydraulic brake system. Vacuum boosters are classified into two types (fig.7-22)— atmospheric suspended and vacuum suspended. The descriptions of the two types are as follows:

- An atmospheric suspended brake booster (fig. 7-22) has normal air pressure on both sides of the diaphragm when the brake pedal is released. As the brakes are applied, a vacuum is formed in one side of the booster. Atmospheric pressure then pushes on and moves the diaphragm.

- An vacuum suspended brake booster (fig. 7-22) has vacuum on both sides of the diaphragm when the brake pedal is released. Pushing down on the brake pedal releases vacuum on one side of the booster. The difference in air pressure pushes the diaphragm for braking action.

Air has a weight of approximately 15 pounds per square inch at sea level. The weight of the air or atmospheric pressure is what is used to operate the vacuum booster.

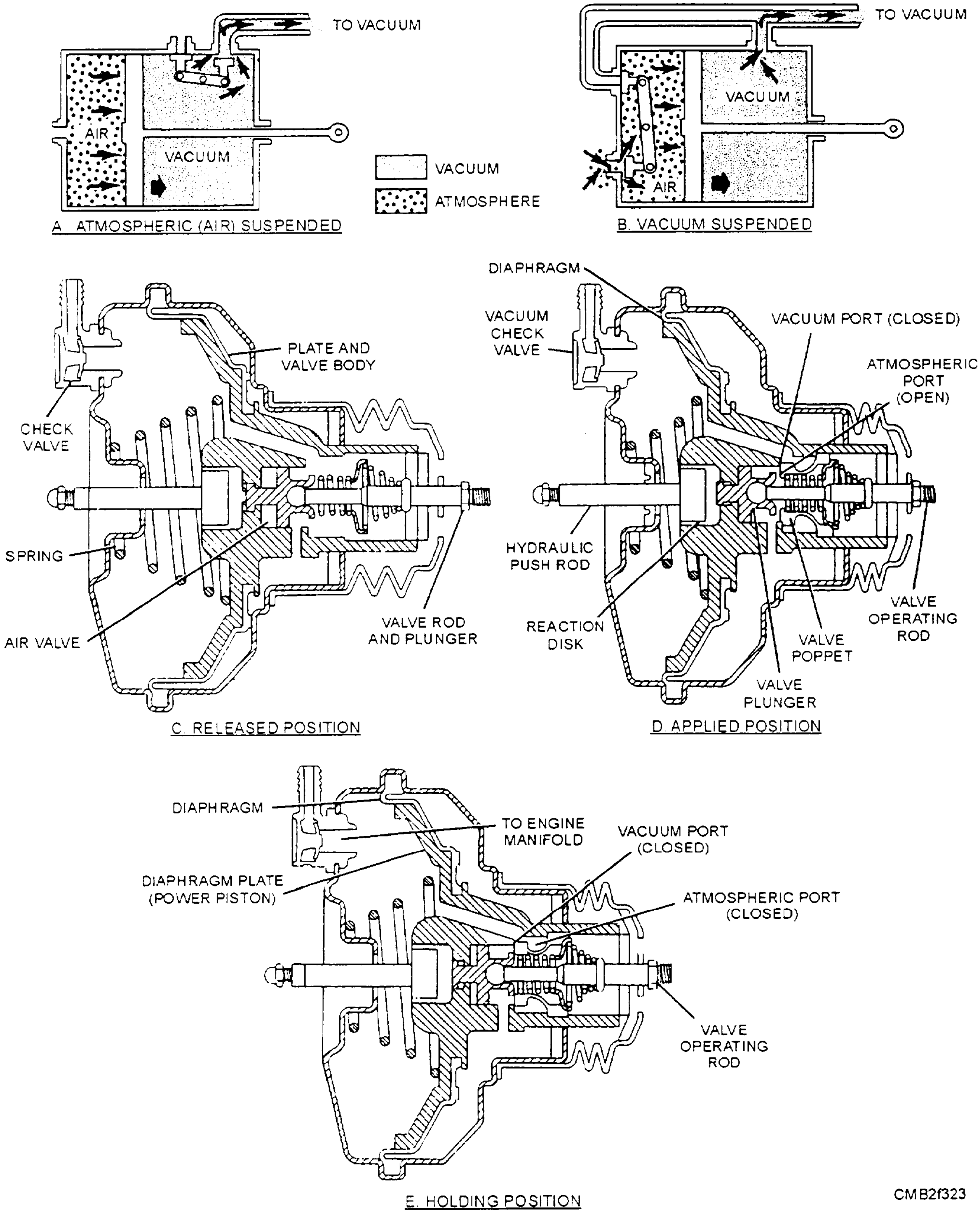


Figure 7-22.—Vacuum power booster and operation.

It is impossible to create a perfect vacuum, but by pumping air from a container, it is possible to obtain a difference in pressure between the outside and inside of the container. or a partial vacuum. If the container were suddenly opened, outside air would rush into the container to equalize the pressure. It is upon this principle that the power cylinder of a vacuum booster system operates.

The power brake operates during three phases of braking application—brakes released, brakes applied, and brakes holding. The operations of a typical vacuum-suspended power booster are as follows:

- RELEASED POSITION (fig. 7-22)—With the brakes fully released and the engine operating, the rod and plunger return spring moves the valve operating rod and valve plunger to the right. As this happens, the right end of the valve plunger is pressed against the face of the poppet valve, closing off the atmospheric port and opening the vacuum port. With the vacuum port opened, vacuum is directed to both sides of the diaphragm, and the return spring holds the diaphragm away from the master cylinder.

- APPLIED POSITION (fig. 7-22)—As the brake pedal is depressed, the valve operating rod moves to the left, which causes the valve plunger to move left also. The valve return spring is then compressed as the plunger moves and the poppet valve comes in contact with the vacuum port seat. As this happens, the vacuum port closes off. Continued application of the brake pedal causes the valve rod to force the valve plunger from the poppet, thereby opening the atmospheric port. Atmospheric pressure then rushes into the control vacuum chamber and applies pressure to the hydraulic pushrod.

- HOLDING POSITION (fig. 7-22)—As the operator stops depressing the brake pedal, the plunger will also stop moving. The reaction of the brake fluid transmitted through the reaction disc now will shift the valve plunger slightly to the right, shutting off the atmospheric port. As this position is held, both sides of the diaphragm contain unchanging amounts of pressure, which exerts a steady amount of pressure on the cylinder piston.

On many installations a vacuum reservoir is inserted between the power booster and the intake manifold. The purpose of the reservoir is to make vacuum available for a short time to the booster unit should the vehicle have to stop quickly with a stalled engine. A check valve in the reservoir maintains a uniform vacuum within the system should engine vacuum drop off. This check valve prevents vacuum from bleeding back to the intake manifold when manifold vacuum is less than the vacuum in the reservoir.

All modern power brakes retain some pedal resistance, permitting the operator to maintain a certain amount of pedal feel. For example, a light pressure upon the pedal will give a light braking force, while heavy pressure upon the brake pedal will cause severe brake application. If the vacuum section of the power booster should fail, brake application can still be obtained by direct mechanical pressure on the master cylinder piston. However, the operator must apply a greater force to the brake pedal to achieve even minimal braking force.

The vacuum-hydraulic power booster, used in most passenger vehicles and light trucks, is of the integral type, so-called because the power booster and the master cylinder are combined in a single assembly. The most common integral types all use a single or tandem diaphragm (fig. 7-23) and are of the vacuum suspended type. The power unit uses a master cylinder constructed in the same manner as the conventional dual master cylinder.

If brake trouble is encountered, check the brake system in the same manner as for conventional brakes. When a vehicle has vacuum type power brakes, you should inspect the brake booster and vacuum hose. Make sure the vacuum hose from the engine is in good condition. It should not be hardened, cracked, or swollen. Also check the hose fitting in the booster. If the system is not performing properly, you should check the power booster for correct operation as follows:

- Stop the engine and apply the brakes several times to deplete the vacuum reserve in the system.

- Partly depress the brake pedal, and while holding it in this position, start the engine.

- If the booster is operating properly, the brake pedal will move downward slightly. If no action is felt, the booster is not functioning.

If the power unit is not giving enough assistance, check the engine vacuum. If engine vacuum is abnormally low (below 14 inches at idle), tune up the engine to raise the vacuum reading and again try the brakes. A steady hiss, when the brake pedal is depressed, indicates a vacuum leak, preventing proper operation of the booster.

Vacuum failure, which results in a hard pedal, may be due to a faulty check valve, a collapsed vacuum hose to the intake manifold, or an internal leak in the power booster.

A tight pedal linkage (insufficient pushrod clearance) will also result in a hard pedal. If this connection is free and the brakes still fail to release properly, the power booster must be replaced.

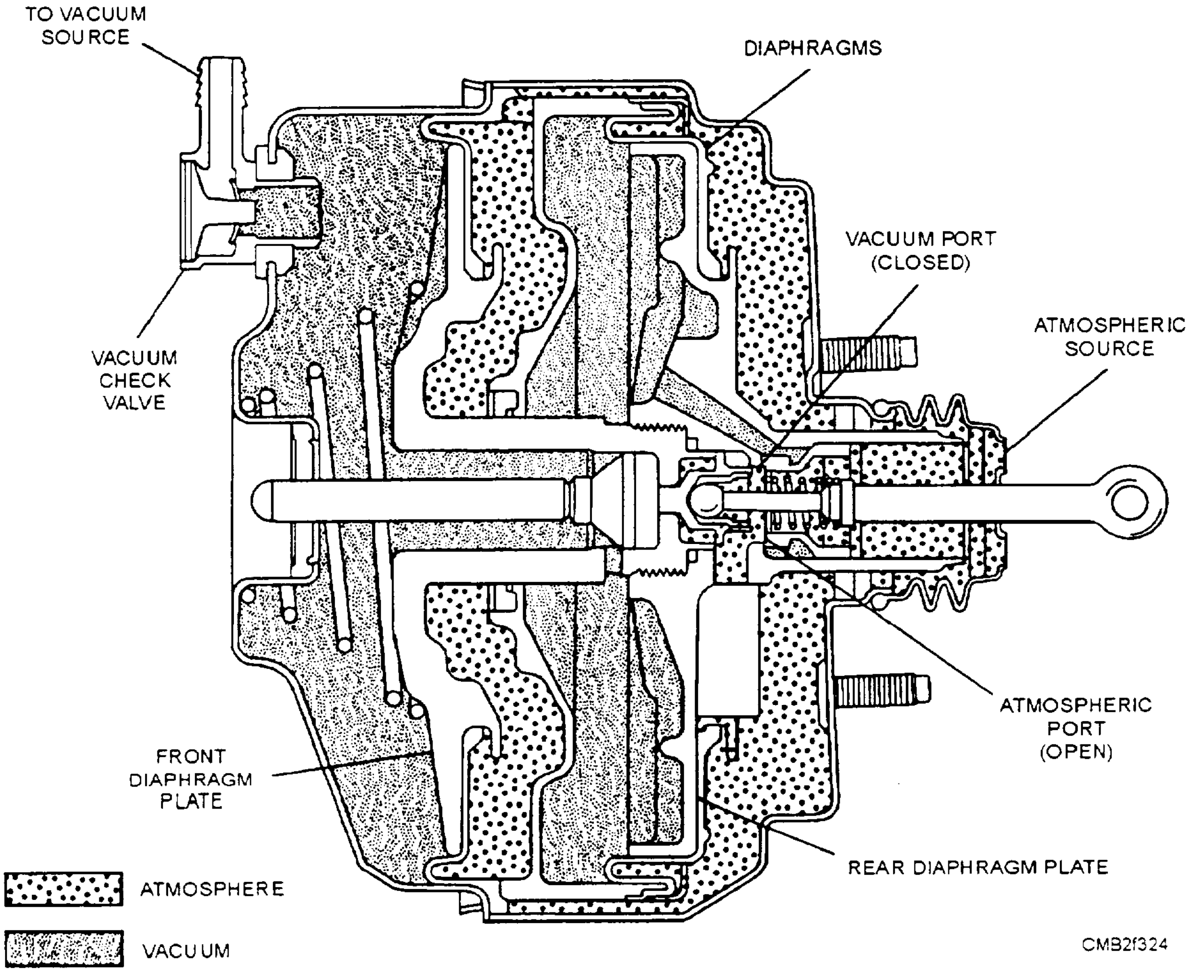


Figure 7-23.—Tandem-type booster.

In addition to hydraulic system problems, the brakes may fail to release as a result of a blocked passage in the power piston, a sticking air valve, or a broken air valve spring.

Any malfunction occurring in the power booster will require removing the booster from the vehicle for repair or replacement. Some power boosters may be rebuilt or repaired; others are sealed and cannot be disassembled. Should you have any questions concerning repairs on the power brake system you are working on, consult the manufacturer's service manual for proper procedures to follow when testing or repairing a unit.

Hydraulic Boosters

The hydraulic-power booster, also called a hydroboost (fig. 7-24), is attached directly to the master cylinder and uses power steering pump pressure to assist the operator in applying the brake pedal. The hydraulic booster contains a spool valve that has an open center that controls the pump pressure as braking occurs. A lever assembly has control over the valve position and the boost piston provides the necessary force that operates the master cylinder. See figure 7-25 for a parts breakdown of a booster assembly.

The hydroboost system has an accumulator built into the system. The accumulator, which is either spring-loaded or pressurized gas, is filled with fluid and pressurized whenever the brakes are applied. Should the power steering system fail because of lack of fluid or a broken belt, the accumulator will retain enough fluid and pressure for at least two brake applications.

PARKING BRAKES

Parking/emergency brakes are essential to the safe operation of any piece of automotive or construction equipment. Parking brakes interconnected with service brakes are usually found on automotive vehicles (fig. 7-26). A foot pedal actuates this type of parking/emergency brake or a dash-mounted handle.

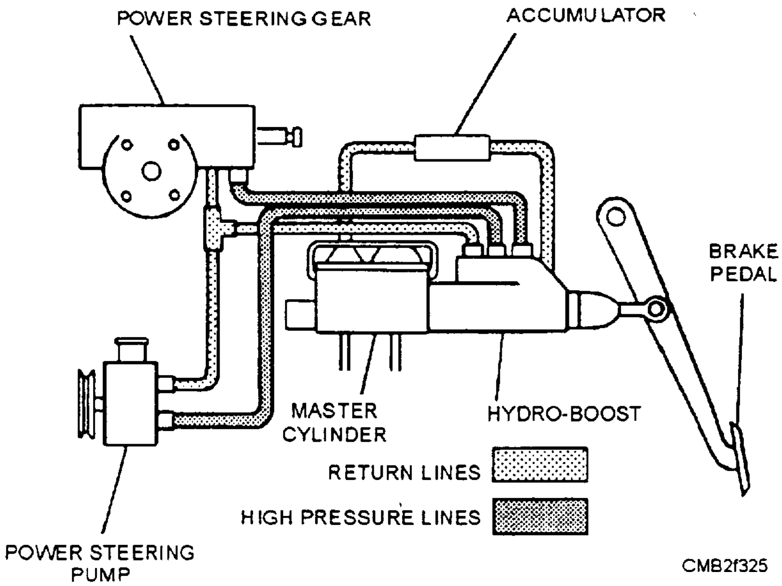


Figure 7-24.—Hydraulic power booster system.

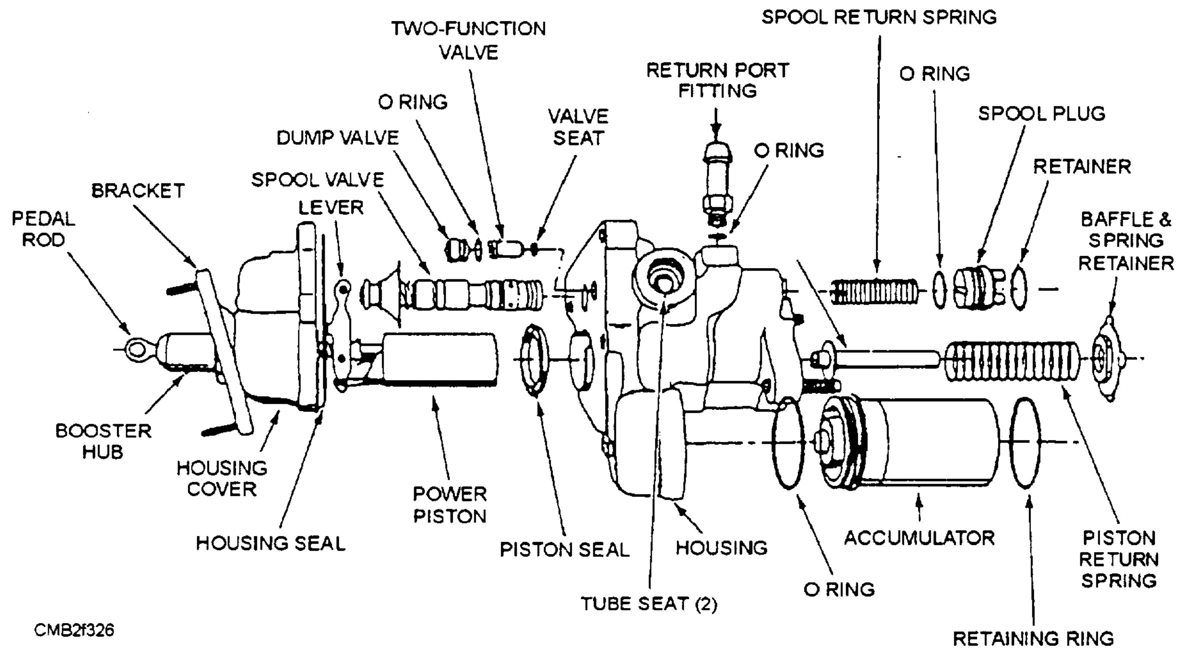


Figure 7-25.—Hydraulic power booster assembly.

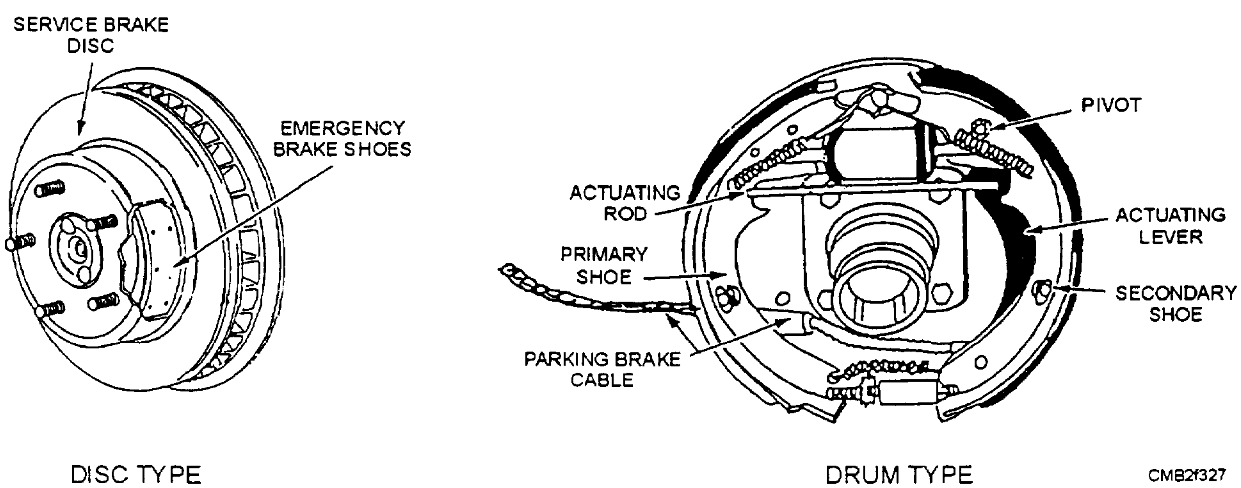


Figure 7-26.—Automotive type parking/emergency brakes, axle mounted.

They are connected through a linkage to an equalizer lever (fig. 7-27) rod assembly, and cables connected to the parking/emergency brake mechanism within the drums/discs (fig. 7-26) at the rear wheels.

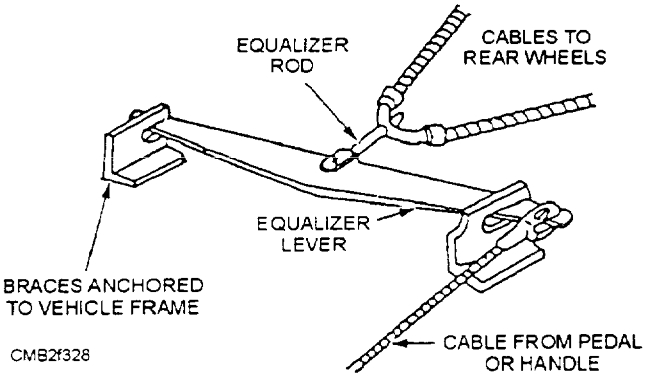


Figure 7-27.—Equalizer linkage.

Several types of parking/emergency brakes are manufactured for construction equipment, such as the external contracting, the drum, and the disc types (fig. 7-28). These are drive line brakes common to heavy construction equipment. They are usually mounted on the output shaft of the transmission or transfer case directly in the drive line.

Theoretically, this type of system is preferred for heavy equipment because the braking force is multiplied through the drive line by the final drive ratio. Also, braking action is equalized perfectly through the differential. There are some drawbacks to this system, however—severe strain is placed on the transmission system, and also the vehicle may move when being lifted since the differential is not locked out.

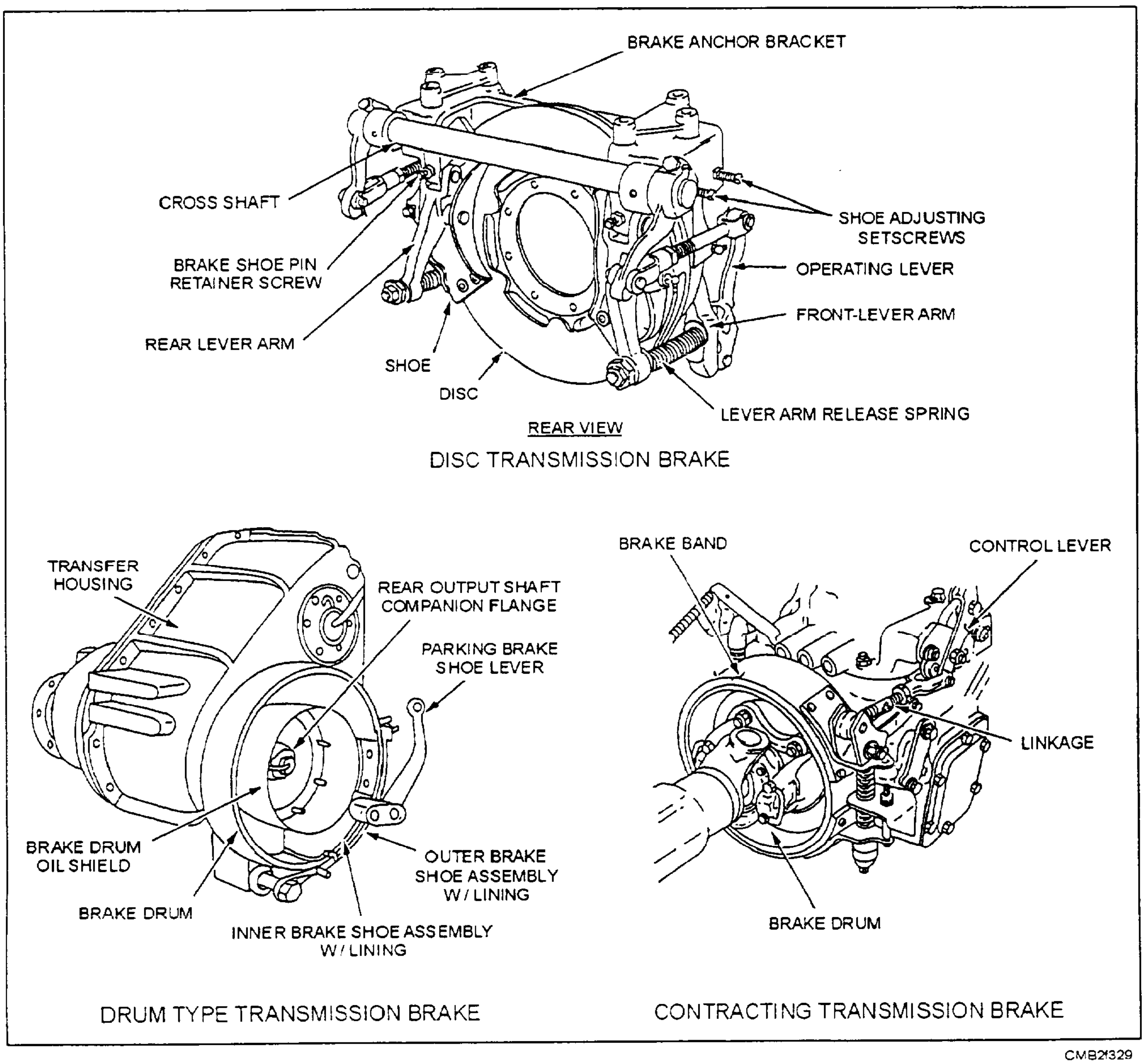


Figure 7-28.—Examples of drive line parking/emergency brakes, transmission mounted.

The parking/emergency brake must hold the vehicle on any grade. This requirement covers both passenger and commercial motor vehicles equipped with either the enclosed type brake at each rear wheel or a single brake mounted on the drive line. The *Federal Motor Carrier Safety Regulations Pocketbook*, par. 393-52. lists emergency brake requirements.

BRAKE SYSTEM INSPECTION

Most vehicle manufacturers recommend periodic inspection of the brake system. This involves checking the fluid level in the master cylinder, brake pedal action, condition of the lines and hoses, and the brake assemblies. These checks are to be performed during the preventive maintenance (PM) cycle.

Checking Master Cylinder Fluid Level

An important part of the brake system inspection is checking the level of the brake fluid. To check the fluid, remove the master cylinder cover, either by unbolting the cover or prying off the spring clip. The brake fluid level should be 1/4 inch from the top of the reservoir.

CAUTION

Use only the manufacturer's recommended type of brake fluid. Keep grease, oil, or other contaminates out of the brake fluid. Contamination of the brake fluid can cause deterioration of the master cylinder cups, resulting in a sudden loss of braking ability.

Brake Pedal Action

A quick and accurate way to check many of the components of the brake system is by performing a brake pedal check. Applying the brake pedal and comparing its movement to the manufacturer's specifications does this. The three brake pedal application distances are as follows:

- BRAKE PEDAL FREE PLAY, which is the amount of pedal movement before the beginning of brake application. It is the difference between the "at rest" and initially applied position. Free play is required to prevent brake drag and overheating. If pedal free play is NOT correct, check the adjustment of the master cylinder pushrod. If this adjustment is correct, check for a worn pedal bushing or a bad return spring, which can also increase pedal free play.

- BRAKE PEDAL HEIGHT, which is the distance from the pedal to the floor with the pedal at rest. If the height is incorrect, there may be worn pedal bushings, weak return springs, or a maladjusted master cylinder pushrod.

- BRAKE PEDAL RESERVE DISTANCE, which is measured from the floor to the brake pedal with the brake applied. The average brake pedal reserve distance is 2 inches for manual brakes and 1 inch for power brakes. If the reserve distance is incorrect, check the master cylinder pushrod adjustment. Also, there may be air in the system or the automatic brake adjusters may not be working.

Brake System Leaks

If the fluid level in the master cylinder is low, you should check the system for leaks. Check all brake lines, hoses, and wheel cylinders. Brake fluid leakage will show up as a darkened, damp area around one of the components.

Checking Brake Assemblies

When inspecting the brake system, remove one of the front and rear wheels. This will let you inspect the condition of the brake linings and other components.

INSPECTING DISC BRAKES.—Areas to check when inspecting disc brakes are the pads, the disc, and the caliper. You should check the thickness of the brake pad linings. Pads should be replaced when the thinnest (most worn) part of the lining is approximately 1/8 inch thick.

Check the caliper for fluid leakage at the piston seal and missing or damaged clips/springs. The disc should be checked for damage, such as heat cracks, heat checks (overheating causes small hardened and cracked areas), and scoring. Wheel bearings should be checked and adjusted if necessary. To check for rattles, strike the caliper with a soft-faced rubber mallet. To repair any of these problems, consult the manufacturer's service manual.

INSPECTING DRUM BRAKES.—Areas to check when inspecting drum brakes are the brake shoes, the brake drums, the wheel cylinders, and other related parts. Once the wheel is removed, you must remove the brake drum that will expose all parts requiring inspection.

The brake shoe linings must NOT be worn thinner than 1/16 inch. They also should NOT be glazed or coated with grease, brake fluid, or differential fluid. Any of these conditions require lining replacement.

Check the brake drum for cracks, heat cracks. heat checks, hard spots, scoring, or worn beyond specifications. Damaged drums may be machined (turned) as long as they still meet the manufacturer's specifications. Badly damaged or worn drums must be replaced.

To check the wheel cylinder for leakage, pull back the cylinder boots. If the boot is full of fluid, the wheel cylinder should be rebuilt or replaced. Also, check the return springs and the automatic adjusting mechanism.

SERVICING THE MASTER CYLINDER

When major brake service is being performed, the master cylinder is to be inspected for proper operation. A faulty master cylinder usually leaks externally out the rear piston or leaks internally. You are able to detect external brake fluid leaks by checking the master cylinder boot for fluid or dampness on the firewall. When the leak is internal. the brake pedal will slowly move to the floor. Inoperative valves in the master cylinder are also a reason for service.

To remove the master cylinder, disconnect the brakes lines from the master cylinder using tubing wrenches. With the brake lines disconnected, unbolt the master cylinder from the brake booster or firewall. In some cases. the pushrod must be disconnected from the brake pedal.

Many shops, however, simply, replace a bad master cylinder with a factory rebuild or a new one. A replacement master cylinder is normally cheaper than the labor cost and parts for an in-shop rebuild.

NOTE

NCF units require replacement of faulty master cylinders. Rebuilding of master cylinders is NOT authorized.

To rebuild a master cylinder, drain the fluid from the reservoir. Disassemble the master cylinder following the instructions in the manufacturer's service manual. After disassembly, clean the parts in brake fluid or a recommended cleaner.

WARNING

Do NOT clean the hydraulic parts of the brake system with conventional parts cleaners. They can destroy the rubber cups in the brake system. Only use brake fluid or a manufacturer's suggested cleaner (denatured alcohol. for example).

If the cylinder is not pitted, scored, or corroded badly, it may be honed using a cylinder hone. When the cylinder is honed, the hone is ran ONLY once in and out. After honing, measure the piston-to-cylinder clearance, using a telescoping gauge and an outside micrometer or a narrow (1/8" to 1/4" wide) 0.006" feeler gauge. When a feeler gauge is used, if the gauge can be inserted between the cylinder wall and the piston, the master cylinder must be replaced. The cylinder must NOT be tapered or worn beyond the manufacturer's specifications. Replace the master cylinder if the cylinder is not in perfect condition after honing.

Blow-dry all parts with low-pressure compressed air. Blow out the ports and check for obstructions. Lubricate all parts with the recommended brake fluid and assemble the master cylinder, using the manufacturer's service manual.

After the master cylinder is reassembled, it is good practice to bench bleed a new or rebuilt master cylinder before installation on the vehicle. A master cylinder is bled to remove air from the inside of the cylinder. Bench bleeding procedures are as follows:

- Mount the master cylinder in a vise
- Install short sections of brake line and bend them back into each reservoir
- Fill the reservoir with approved brake fluid
- Pump the piston in and out by hand until air bubbles no longer form in the fluid
- Remove the brake lines and install the reservoir cover

Once the master cylinder has been bench bled. it is ready to be reinstalled on the vehicle. Bolt the master cylinder to the booster or firewall. Check the adjustment of the pushrod if there is a means of adjustment provided. Without cross threading the fittings, screw the brake lines into the master cylinder, and lightly snug the fittings. Then bleed (remove air from) the system. Tighten the brake line fittings. Refill the reservoir to the proper level and check brake pedal fall. Last but not least, test the vehicle.

SERVICING DRUM BRAKES

You should understand the most important methods for servicing a drum brake. However. specific procedures vary and you should always consult the manufacturer's service manual. Brake service is required anytime you find faulty brake components. A leaking wheel cylinder, worn linings, scored drum, or other troubles require immediate repairs. A complete drum brake service involves the following:

- Removing, cleaning, and inspecting parts from the backing plate
- Replacing brake shoes
- Resurfacing brake drums
- Replacing or rebuilding wheel cylinders
- Lubricating and reassembling brake parts
- Readjusting, bleeding, and testing the brakes

Servicing Wheel Cylinders

Normally, faulty wheel cylinders aredetected when fluid leaks appear or the pistons stick in the cylinders, preventing brake application. Many shops service the wheel cylinders anytime the brake linings are replaced.

NOTE

NCF units require replacement of faulty wheel cylinders. Rebuilding of wheel cylinders is NOT authorized.

To rebuild a wheel cylinder, remove the boots, the pistons, the cups, and the springs. Most wheel cylinders can be disassembled and rebuilt on the vehicle. However, many manufacturers recommend that the wheel cylinder be removed from the backing plate and serviced on the bench. This makes it easier too properly clean, inspect, and reassemble. A rebuild normally involves honing the cylinder and replacing the cups and boots.

It is important that the cylinder be in good condition. Inspect the cylinder bore for signs of pitting, scoring, or scratching. Any sign of pitting, scoring, or scratching requires cylinder replacement.

A brake cylinder hone is used when honing is required. With the cylinder hone attached to an electric drill, lubricate the hone with brake fluid and insert into the cylinder. Turn the drill on and move the hone back and forth one time ONLY. The cylinder bore must not be honed more than 0.003 inch larger than the original diameter. Replace the cylinder if the scoring cannot be cleaned out or if the clearance between the bore and pistons is excessive.

CAUTION

When honing a wheel cylinder, do not let the hone pull out of the cylinder. The spinning hone can fly apart causing bodily harm. Wear eye protection.

After honing, clean the cylinder thoroughly using clean rags and recommended brake fluid. Make sure the cylinder is clean and in perfect condition before reassembly. The slightest bit of grit or roughness can cause cup leakage.

When reassembling the wheel cylinder, make sure the new wheel cylinder cups are the same size as the originals. Cup size is normally printed on the face of the cup. Lubricate all parts with clean brake fluid and reassemble.

NOTE

Never allow any grease or oil to contact the rubber parts or other internal components. Grease or oil will cause the rubber parts to swell. which will lead to brake failure.

Replacing Brake Shoe Linings

To replace the brake shoes, first remove the wheel and brake drum. With the drum removed, note how the springs and retainers are installed before attempting to remove the shoes from the backing plate. This will assist you during reassembly.

If hydraulic brakes are being repaired, install a wheel cylinder clamp (fig. 7-29) to prevent the pistons from coming out of the wheel cylinder. Next, remove the retracting springs with brake spring pliers or a removal and installation tool (fig. 7-30). The brake

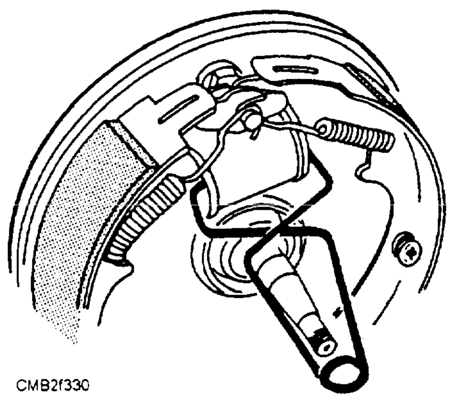


Figure 7-29.—Wheel cylinder clamp in use.

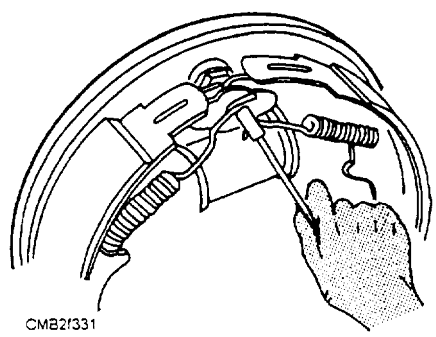


Figure 7-30.—Removal of the brake return springs.

shoe retainers must be removed next. Figure 7-31 shows one type being removed with a pair of ordinary combination pliers. Heavy-duty brake shoes are mounted on separate anchor pins. Some of these installations require the removal of the anchor pins, while others require the removal of clips on the end of these pins before the brake shoes can be removed.

On light-duty applications, you can now grasp the shoes (fig. 7-32) and lift them off the backing plate. After they are removed, allow the shoes to move together (fig. 7-33). This allows easy removal of the spring and adjusting screw assembly. Disassemble the adjusting screw and lubricate with a high-temperature lubricant.

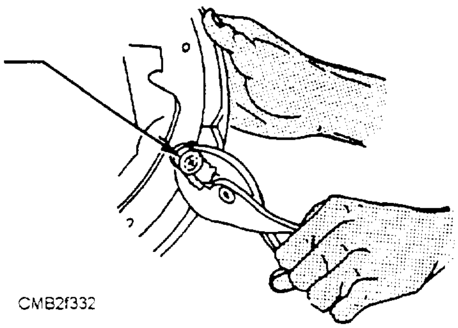


Figure 7-31.—Removal of a brake shoe retainer.

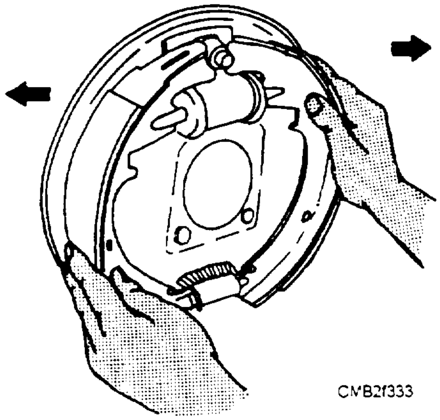


Figure 7-32.—Removing shoes from the backing plate.

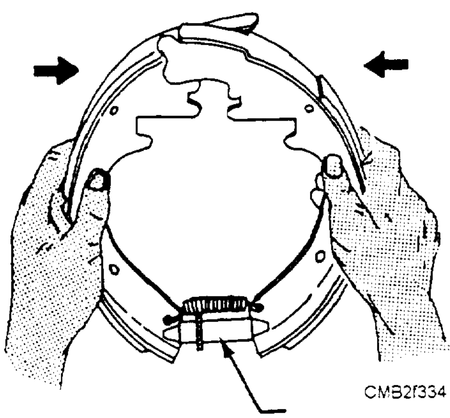


Figure 7-33.—Removing adjusting screw assembly.

If the lining is riveted and is to be replaced, you should mark the front and rear shoe. This action will aid in reassembly. Wipe off the backing plate thoroughly with a rag. If the backing plate is coated with brake fluid or axle lubricant, wash it with an approved cleaner. Once the backing plate is clean, apply a light coat of high-temperature lubricant to the raised pads on the backing plate. This will keep the shoes from squeaking after they are reassembled. Avoid using too much lubricant or the linings can become contaminated and ruined.

New linings are secured to the shoes by riveting or bonding. Bonded brake linings are supplied with the linings already attached to the shoes. At some activities, the old shoes must be exchanged when issued new shoes from the parts room. Linings that require rivets to attach the linings to the shoes are provided in kits. These kits provide enough linings and rivets for one or more wheels. The linings are predrilled and countersunk for the rivets and arced to match the brake shoes.

Some shops have specialized equipment to remove and replace the riveted linings. However, if the equipment is not available. the old linings can be removed with a drill and oversized bit, punch, and hammer. Take care not to enlarge the rivet holes in the shoes. If the rivet holes are enlarged, the shoe should be discarded.

Most NCF shops have a device for installing rivets. This device comes with adapters for use with various size rivets. When installing rivets. you always start in the center of the lining and work alternately to each end. Make sure the rivets are tight enough to hold the lining securely without splitting the lining at the rivet holes.

For installation of the new shoes, refer to the manufacturer's service manual. Your service manual will have illustrations for the particular brake design being serviced. Use them to ensure all parts are positioned correctly, on the backing plate. When reassembling the brake assemblies, ask yourself the following questions:

- Are the wheel cylinders in perfect condition and assembled properly?
- Did I lubricate the backing plate and star wheel?
- Is the primary (smaller) lining facing the front of the vehicle and the secondary (larger) lining facing the rear?

- Are the brake shoes centered on the backing plate and contacting the anchor pin correctly?
- Are all springs installed properly?
- Does the automatic adjusting mechanism work?
- Are the linings perfectly clean (sand if needed)?
- Do I need to bleed the brakes?

Servicing Brake Drums

With the drum removed, inspect the shoes to determine the condition of the drum. For instance, if the linings are worn thin on one side, the drums are likely to be tapered or bell-shaped. Linings with ridges in their contact surfaces point out the need for resurfacing (turning) the drum to remove the matching ridges.

Resurfacing is needed when the drum is scored, out-of-round, or worn unevenly. Some shops resurface a drum anytime the brake linings are replaced, others only when needed. Drums are resurfaced using a lathe in the machine shop of an NMCB and at some shore installations. Commercial brake drum lathes can be found in some shops. Make sure you know how to operate the lathe before attempting to resurface a drum. Using the wrong procedures will damage the drum and possible deadline the vehicle.

Before resurfacing the drum, check the specifications that are cast into the drum (fig. 7-34) or are provided in the maintenance manual. These specifications tell you the maximum amount of surface material that can be removed from the drum and still provide adequate braking. Typically, a brake drum should not be more than .060 inch oversize. For esample. a drum that is 9 inches in diameter, when new, must not be over 9.060 after resurfacing. To measure brake drum diameter, use a special brake drum micrometer (fig. 7-35). It will measure drum

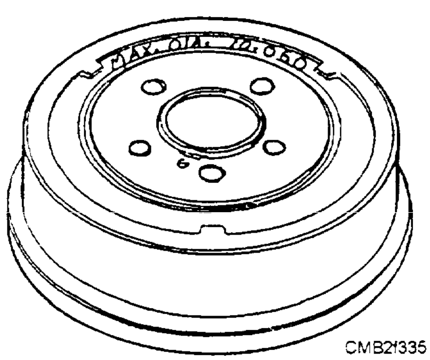


Figure 7-34.—Example of specification cast into a brake drum.

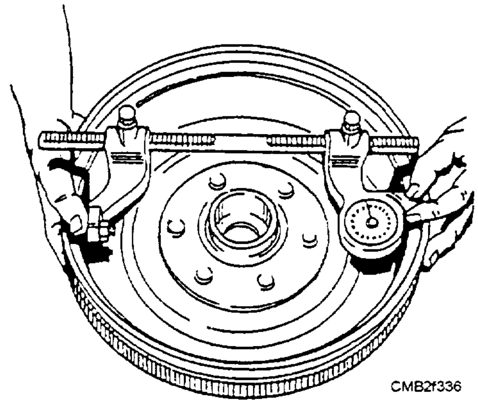


Figure 7-35.—Using a drum micrometer to measure a brake drum.

diameter quickly and accurately. Replace the drum if it is worn beyond specifications.

For maximum braking efficiency after the drums have been resurfaced, the arc of the shoes must match the drums. This means that the linings must be ground to match the curvature of the drum when it is resurfaced. There should be a small clearance between the ends of the lining and the drum. The shoes should rock slightly when moved in the drum. If the center of the linings is not touching the drum, the linings should be arced (ground). Shops equipped with a commercial brake lathe have a special attachment to perform this task. If no attachment is available, the shoes can be installed but the brakes will not become fully effective until the linings wear enough to match the braking surface of the drum. Frequent adjustments will be needed until they wear sufficiently.

SERVICING DISC BRAKES

All disc brake services begin with sight, sound, and stopping test. The feel of the brake pedal adds a check on the condition of the hydraulic system.

Stopping the vehicle will indicate whether the brakes pull in one direction, stop straight, or require excessive effort to stop. Listening while stopping permits a fair diagnosis of braking noises, such as rattles, groans, squeals, or chatters. Visually inspecting the parts provides valuable information on the condition of the braking system.

A complete disc brake service typically involves four major operations, which are as follows:

- Replacing worn brake pads
- Rebuilding the caliper assembly
- Resurfacing the brake discs
- Bleeding the system

Depending on the condition of the parts, the mechanic may need to do one or more of the operations. In any case. you must make sure the brake assembly is in sound operating condition.

Disc Brake Pad Replacement

Disc brakes have flat linings bonded to a metal plate or shoe. The pad is not rigidly mounted inside the caliper assembly; thus, it is said to float. These pads are held in position by retainers or internal depressions (pockets machined into the caliper).

A visual inspection on the condition of the pads can be made after the wheel and tire is removed. The inner shoe and lining can be viewed through a hole in the top of the caliper, whereas the outer shoe and linings can be viewed from the end of the caliper.

A good rule in determining the need for pad replacement is to compare lining thickness to the thickness of the metal shoe. If the lining is not as thick as the metal shoe, it should be replaced. The basic steps for disc brake service are as follows:

1. Siphon two thirds of the brake fluid from the master cylinder. This action prevents fluid overflow when the caliper piston is pushed back.

7. Remove the caliper guide pins that holds the caliper to the adapter. In typical applications, positioners and bushings will come off with the pins.

3. Lift the caliper off the adapter and away from the rotor. Do NOT let the caliper hang by the brake hose. Hook or tie the caliper to a suspension member. This will allow the rotor to be tested and inspected.

4. Remove old pads from the caliper and adapter. Note the position of antirattle clips because they may be reused if they are in good condition.

5. Using a C-clamp or large screwdriver. force the piston back into the caliper. This action will open the caliper wide enough for new, thicker pads.

6. Install the antirattle clips on the new pads. Fit the pads back into the caliper.

7. Slide the caliper assembly over the rotor. Assemble the caliper mounting hardware in reverse order of disassembly. Make sure all bolts are torqued to the manufacturer's specifications.

8. After new pads are installed, road test the vehicle to make sure that the brakes are operating properly and also seat the new pads. Several (3 to 3) heavy braking applications will work.

NOTE

It is acceptable to service just the rear or front disc brakes. However. NEVER service only the left or right brake assemblies; always replace both sets to assure equal braking action.

Since disc brake systems vary, consult the vehicle manufacturer's service and repair manuals for specific details on the type of disc brakes you are working on.

Servicing Caliper Assemblies

When a caliper is frozen, leaking, or has extremely high mileage, it is to be serviced. Servicing disc brake caliper assemblies involve the replacement of the piston, seals, and dust-boots. To perform this type of service. it is necessary to remove the caliper assembly from the vehicle. Basic steps for servicing the caliper assemblies are as follows:

1. Remove the piston from the caliper by using air pressure to push the piston from the cylinder. Keep your fingers out of the way when using compressed air to remove the pistons from the caliper. Serious hand injuries can result.

2. With the piston removed, pry out the old dust boot and seal from the caliper. Keep all parts organized on the workbench. Do not mix up right and left side or front and rear parts.

3. Check the caliper cylinder wall for scoring. pitting, and wear. Light surface imperfections can usually be cleaned with *a* cylinder hone or emery cloth. When honing, use brake fluid to lubricate the hone. If excessive honing is required, replace the caliper.

4. Check the piston for wear and damage. If any problems are found, replace the piston. The piston and cylinder are critical and must be in perfect condition.

5. Clean all parts with an approved cleaner. Wipe the parts with a dry, clean rag. Then coat the parts with brake fluid.

6. Assemble the caliper in reverse order of disassembly. Using new seals and boots, fit the

new seal in the cylinder bore groove. Work the seal into its groove with your fingers. Install the new boot in its groove. Coat the piston with more brake fluid. Spread the boot with your fingers and slide the piston into the cylinder. The caliper can now be reinstalled on the vehicle.

Carefully follow the procedures given in the manufacturer's service and repair manuals for specific details when removing, repairing, and reinstalling disc brake caliper assemblies.

Brake Disc (Rotor) Service

It is important to check the condition of the brake disc when servicing the brake system. Vehicle manufacturers provide specifications for minimum disc thickness and maximum disc runout. The disc must also be checked for scoring, cracking, and heat checking. Disc resurfacing is required to correct runout, thickness variation, or scoring.

MEASURING DISC THICKNESS.—To measure disc thickness, use an outside micrometer. Disc thickness is measured across the two friction surfaces in several locations. Variation in disc thickness indicates wear. Compare your measurements to the manufacturer's specifications.

Minimum disc thickness will sometimes be printed on the side of the disc (fig. 7-36). If not, refer to the manufacturer's service manual or a brake specification chart. If disc thickness is under specifications. replace the disc, because a thin disc cannot dissipate heat properly and may warp or fail during service.

BRAKE DISC RUNOUT.—The amount of side-to-side movement, measured near the outer friction surface of the disc, is known as brake disc runout. Runout is measured using a dial indicator.

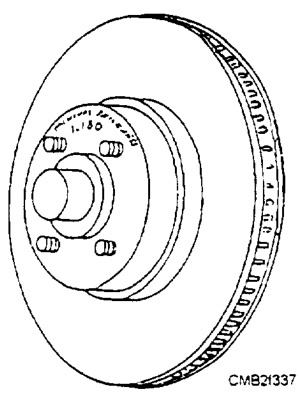


Figure 7-36.—Example of minimum thickness specification cast into a brake disc.

Using a magnetic base, attach the dial indicator to the hub. Position the dial indicator so it touches the face of the disc. Rotate the disc by hand and read the indicator.

Compare the indicator reading to factory specifications. Typically, disc runout should not exceed .004 inch. If runout is beyond specifications, resurface the disc to its true friction surface.

RESURFACING A BRAKE DISC.—When a disc is in good condition, most manufacturers do NOT recommend disc resurfacing. Disc resurfacing is done when absolutely necessary.

When using a brake lathe to resurface a brake disc, you use the appropriate spacers and cones to position the disc on the arbor of the machine. Wrap a spring or rubber damper around the disc to prevent vibration. Follow the directions provided with the brake lathe.

WARNING

Do not attempt to operate a brake lathe without first obtaining proper training. Damage to the machine or injury to the operator can occur as a result of incorrect operating procedures.

Only take off enough metal to true the disc. Then without touching the machined surfaces with your fingers, remove the disc. This prevents body oil from penetrating the machined surfaces. Check the disc for thickness and reinstall on the vehicle.

BRAKE SYSTEM BLEEDING

Brake system bleeding is the use of fluid pressure to force air from the system. The brake system must be free of air to function properly. Air in the system will compress, causing a springy or spongy brake pedal. Air may enter the system any time a hydraulic component (wheel cylinder, master cylinder, hose, or brake line) is disconnected or removed. There are two methods of bleeding brakes—manual bleeding and pressure bleeding.

Manual Bleeding

Manual bleeding uses master cylinder pressure to force fluid and trapped air out of the system. To bleed the system, proceed as follows:

- Fill the master cylinder reservoir with brake fluid to 1/4 inch from the top, and keep it full during bleeding operations.

- Attach a short length of a rubber hose to the wheel cylinder bleeder screw and allow the other end of the hose to be submerged in a jar halfway filled with brake fluid (fig. 7-37).
- Have an assistant push on the brake pedal to apply pressure on the brake system. It may be necessary to pump the brake six to seven times to build up pressure in the system.
- Open the bleeder screw while watching for air bubbles in the fluid located in the jar.
- Close the bleeder screw and tell your assistant to release the brake pedal. Repeat this procedure until no air bubbles come out of the hose.

Bleed one wheel cylinder at a time. Do the one farthest away from the master cylinder first and work your way to the closest. This ensures that all the air possible can be removed at the first bleeding operation.

Pressure Bleeding

Pressure bleeding of a brake system is preferred to the method just described but requires equipment of the type shown in figure 7-38. Pressure bleeding a brake system is done using air pressure trapped inside a metal air tank (bleeder ball). Pressure bleeding is quick and easy because of the following:

- It does not require an assistant.
- It maintains a constant pressure in the system.
- It keeps the master cylinder full during bleeding

To pressure bleed the system, proceed as follows:

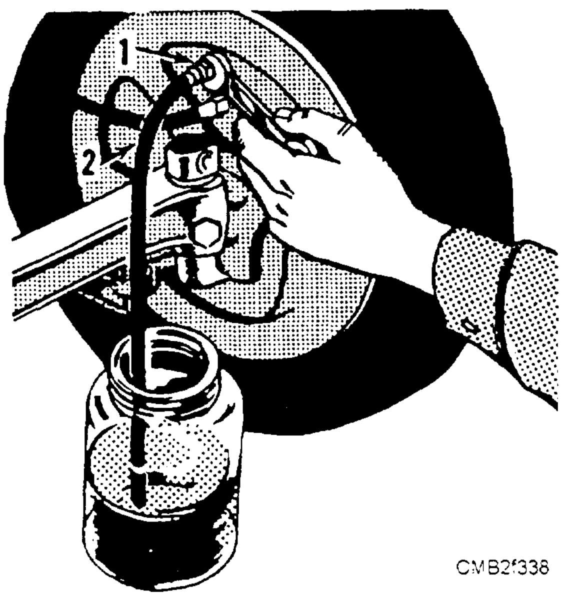


Figure 7-37.—Manual bleeding brake lines: (1) Bleeder screw: (2) Bleeder hose.

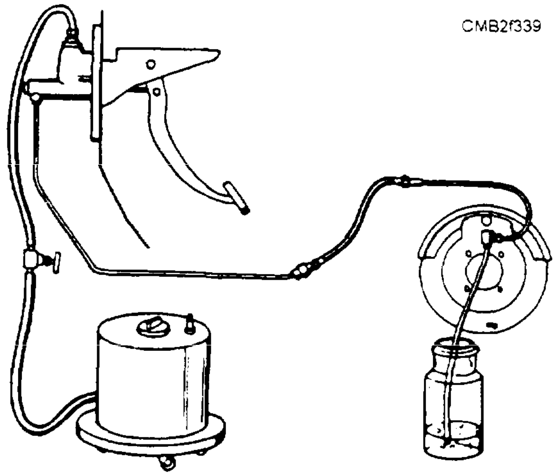


Figure 7-38.—Pressure bleeding a brake system.

- Pour enough brake fluid in the bleeder ball to reach the prescribed level. Charge the ball with 10 to 15 psi of air pressure.
- Fill the master cylinder with brake fluid. Install the adapter and hose on the master cylinder. Open the valve on the hose.

NOTE

A special pressure-bleeding adapter is required on master cylinders using a PLASTIC RESERVOIR. Use an adapter that seals over the ports in the bottom of the master cylinder. This will avoid possible reservoir damage.

- Attach a bleeder hose to the farthest wheel cylinder bleed screw. Submerge the free end of the hose in a glass container halfway filled with brake fluid.
- Loosen the bleed screw. When fluid coming from the submerged end of the hose is free of air bubbles, close off the bleed screw and remove the bleeder hose. Repeat bleeding operation on the other wheel cylinders in proper order.

When the bleeding operation is completed, close the valve at the bleeder ball hose and disconnect the bleeder from the master cylinder. Check the brake fluid level in the reservoir, ensuring it is within 1/4 inch from the top and install the master cylinder cover.

REVIEW 1 QUESTIONS

Q1. *The time frame between the instant the operator decides to apply the brakes and the moment the brake system is activated is known by what term?*

Q2. What term is used to refer to the comparison of front-wheel to rear-wheel braking effort?

Q3. Typically, what percentage of the braking does the rear brake handle?

Q4. What component of a hydraulic brake system coverts the force of an operator's foot into hydraulic pressure?

Q5. In a vehicle using a dual master cylinder, what type of system operates the brake assemblies on opposite corners?

Q6. What component in a hydraulic brake system is used where a single brake line feeds two wheel cylinders?

Q7. What type of self-adjusting system uses braided steel cable?

Q8. Disc brakes use servo actions. (T/F)

Q9. What are the three types of brake shoes?

Q10. What component of a disc brake system is a nonrotating unit?

Q11. Why is a metering valve used?

Q12. Describe a combination valve.

Q13. What component of an ABS system uses a wheel speed sensor signal to operate the hydraulic actuator?

Q14. What component of an ABS system is mounted on each spindle or hub?

Q15. A hydroboostpower brake system uses pressure from the power steering pump. (T/F)

Q16. What are the three brake pedal application distances?

Q17. At what thickness should disc brake pads be replaced?

Q18. What action should be taken before installing a new master cylinder on a vehicle?

Q19. What device is used to measure brake drum diameter?

Q20. The amount of side-to-side movement of a brake disc is known by what term?

Q21. How much metal is to be removed when resurfacing a brake disc?

Q22. When pressure bleeding a brake system, what is the charging pressure of the bleeder ball?

AIR BRAKE SYSTEM

Learning Objective: Describe the operation, terms, and component functions of an air brake system. Describe the procedures for servicing an air brake system.

Unlike liquids, gases are compressed easily. If a gas, such as air, is contained and a force applied to it, it is compressed and has less volume. Placing a weight on a piston that fits in the container can exert such a force. The air that originally filled the entire container is pressed into only a portion of the container due to the force of the weight upon it. The pressure of the compressed air, resulting from the force exerted upon it by the weight, will be distributed equally in all directions just as it is in a liquid.

An air brake system performs the following basic actions:

- An air pump or compressor driven by the engine is used to compress air and force it into a reservoir where it is forced under pressure and made available for operating the brakes.
- Air under pressure in the reservoir is released to the brake lines by an air valve operated by the brake pedal.
- This released air goes to brake chambers (located at each wheel) that contains a flexible diaphragm. Against this diaphragm is a plate that is connected directly to the mechanism on the wheel brakes by linkage.
- The force of the compressed air admitted to the brake chamber causes the diaphragm to move the plate and operate the brake shoes through the linkage.

Considerable force is available for braking because the operating pressure may be as high as 110 psi. All brakes on a vehicle, and on a trailer when one is used, are operated together by means of special regulating valves. A diagram of a typical air brake system is shown in figure 7-39.

COMPRESSOR, GOVERNOR, AND UNLOADER ASSEMBLY

The COMPRESSOR is driven from the engine crankshaft or one of the auxiliary shafts. The three common methods of driving the compressor from the engine are gear, belt, and chain. The compressor may be lubricated from the engine crankcase or self-lubricating. Cooling may be either by air or liquid

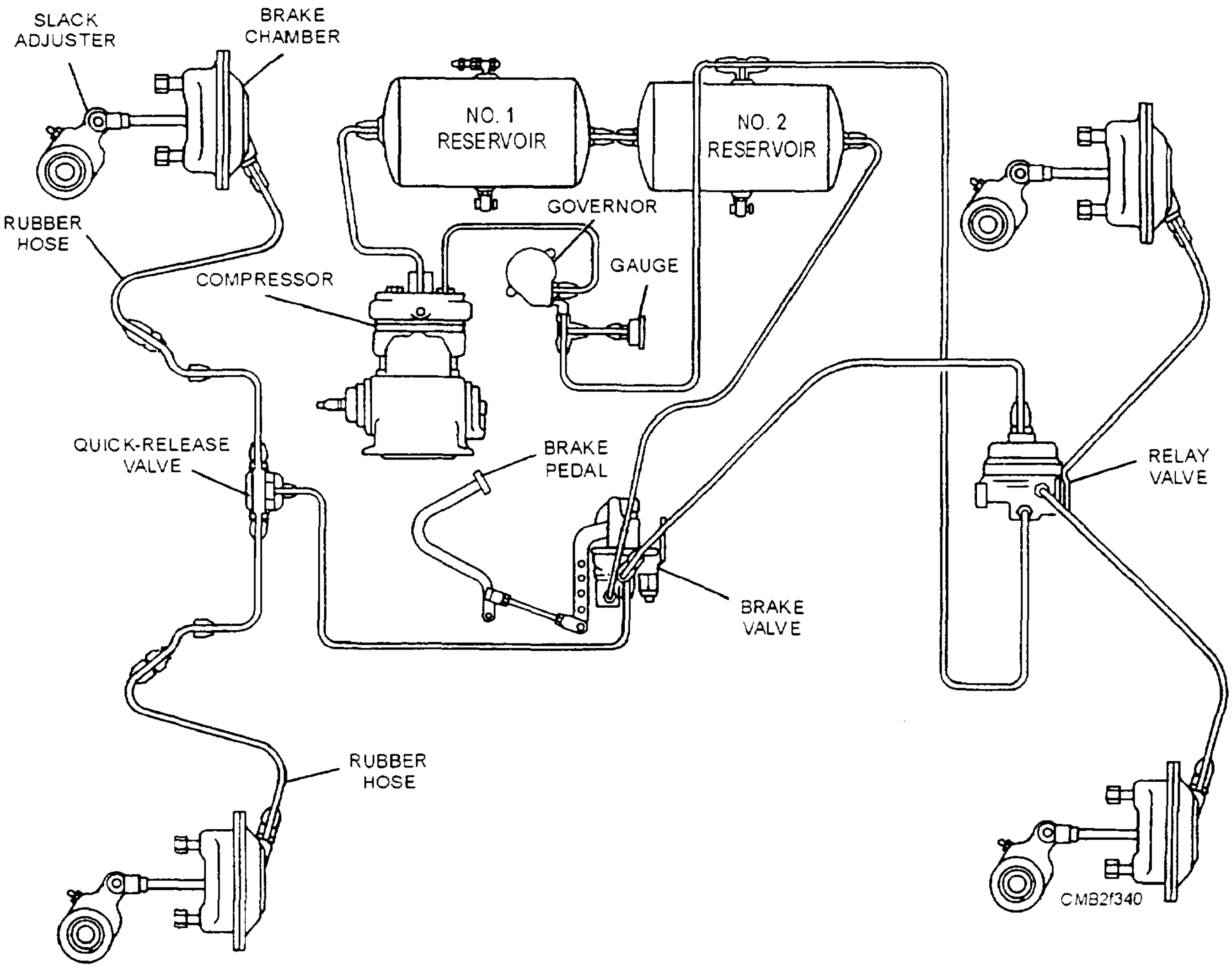


Figure 7-39.—Typical air brake system.

from the engine. Compressors, having a displacement of approximately 7 cubic feet per minute (cfm), have two cylinders, while those with a displacement of 12 cfm have three cylinders.

The reciprocal air compressor (fig. 7-40) operates continuously while the engine is running, but the governor controls the actual compression. The operation of the compressor is as follows:

- The partial vacuum created on the piston downstroke draws air through the air strainer and intake ports into the cylinder.
- As the piston starts its upstroke. the intake ports are closed off, and the air trapped in the cylinder is compressed.
- The pressure developed lifts the discharge valve, and the compressed air is discharged to the reservoirs. As the piston starts its downstroke. pressure is relieved, closing the discharge valve.

The purpose of the compressor GOVERNOR is to maintain the air pressure in the reservoir between the maximum pressure desired (100 to 110 psi) and the minimum pressure required automatically for safe operation (80 to 85 psi) by controlling the compressor unloading mechanism.

In the type O-1 governor (fig. 7-41) air pressure from the reservoir enters the governor through the strainer and is always present below the tower valve and in the spring tube. As the air pressure increases, the tube tends to straighten out and decrease pressure on the valve.

When the reservoir air pressure reaches the cutout setting of the governor (100 to 110 psi), the spring load of the tube on the tower valve has been reduced enough to permit air pressure to raise the tower valve off its seat. This movement of the lower valve raises the upper valve to its seat, which closes the exhaust port. Air then flows up through the small hole in the lower

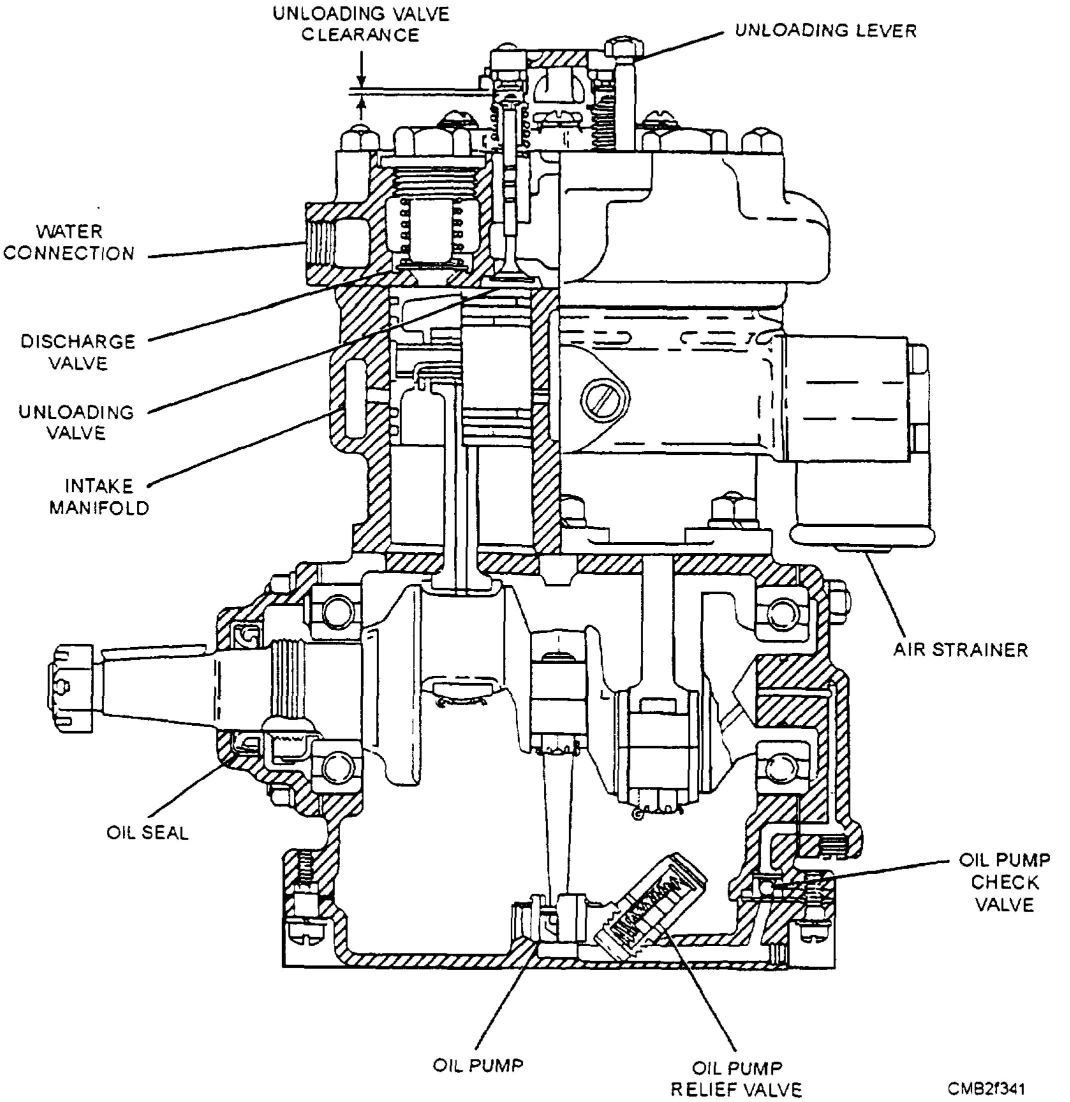


Figure 7-40.—Typical two-cylinder reciprocal air compressor.

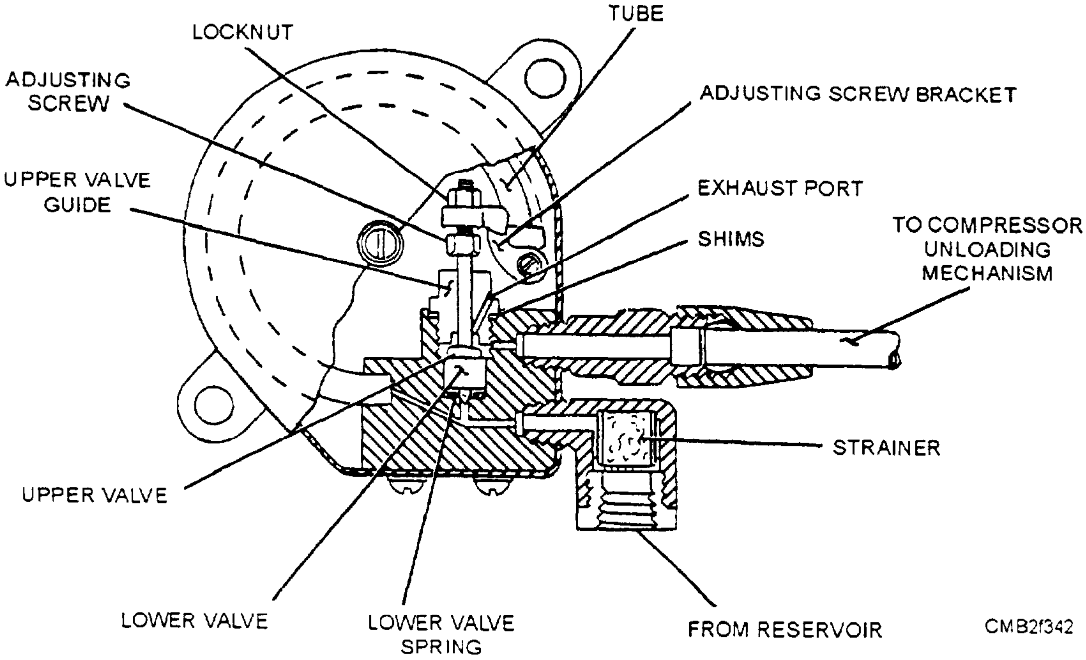


Figure 7-41.—Type O-1 governor.

valve and out the upper connection to the unloader assembly located in the compressor cylinder head. When the unloader valves open, the compression of air is stopped.

When reservoir pressure is reduced to the cut-in setting of the compressor governor (80 to 85 psi), the governor tube again exerts sufficient spring pressure on the valve mechanism to depress and close the lower valve and open the upper valve, thereby shutting off and exhausting the air from the compressor unloading mechanism and compression is resumed.

The pressure range and setting should be checked periodically using an air gauge known to be accurate. Pressure range may be changed in the type O-1 governor by adding shims beneath the upper valve guide to decrease the range, or removing shims to increase the range. Pressure settings may be changed, if necessary, by turning the adjusting screw to the left to increase the setting or to the right to decrease the setting.

The strainer should be removed periodically and cleaned. Check the governor periodically for excessive leakage in both the cut-in and cutout positions. If the governor fails to operate properly, it should be repaired or replaced.

In the type D governor (fig. 7-42) when the reservoir pressure reaches the cut-out setting (100 to 110 psi), the governor diaphragm is subjected to sufficient air pressure to overcome the spring loading. This action allows the valve mechanism to move up, permitting the exhaust stem to close the exhaust valve and to open the inlet valve. Reservoir pressure then passes through the governor to operate the compressor unloading mechanism. stopping further compression of the air compressor.

When the reservoir pressure is reduced to the cut-in setting (80 to 85 psi). the spring loading within the governor overcomes the air pressure under the diaphragm. The valve mechanism is actuated, closing the inlet valve and opening the exhaust valve, thereby shutting off and exhausting the air from the compressor unloading mechanism and compression is resumed.

Pressure range and setting should be checked periodically, using an accurate air gauge. The pressure range (pressure differential) between loading and unloading of the type D governor is a function of the design of the unit and should not be changed. The designed range for this governor is approximately 20 percent of the cutout pressure setting. The pressure settings of the type D governor may be adjusted by turning the adjusting nut clockwise to increase or counterclockwise to decrease the settings.

Both strainers should be removed periodically and cleaned or replaced. The governor should periodically be checked for leakage at the exhaust port in both the cut-in and cutout positions. If the governor fails to operate properly, it should be repaired or replaced.

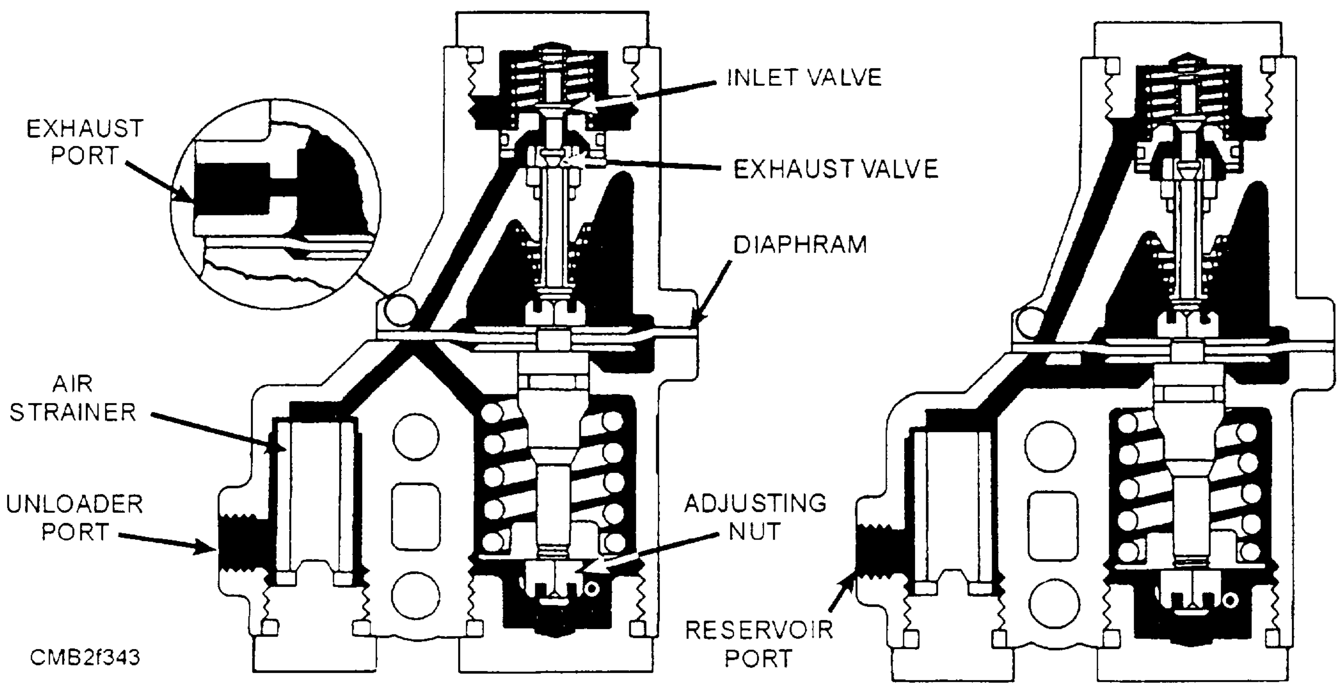


Figure 7-42.—Type D governor.

The UNLOADER assembly (fig. 7-43) is mounted in the compressor head and controlled by the governor. The unloader valve may be either a poppet-type or a spring-loaded control valve. Air pressure from the governor opens the unloader valves to unload or stop compression in the compressor.

When the reservoir air pressure reaches the maximum setting of the governor, air under pressure is allowed by the governor to pass into a cavity below an unloading diaphragm. This air pressure lifts one end of the unloading lever, which pivots on its pin and forces the unloading valves off their seats. With the unloading valves off their seats, the unloading cavity forms a passage between the cylinders above the pistons. Air then passes back and forth through the cavity between the cylinders and compression is stopped. A drop in air pressure below the minimum setting of the governor causes it to release the air pressure from beneath the unloading diaphragm, allowing the unloading valves to return to their seats resuming compression.

AIR TANKS (RESERVOIRS)

The two steel air tanks, commonly known as reservoirs, are used to cool, store, remove moisture from the air, and give a smooth flow of air to the brake system.

At the bottom of each tank is a drain valve (fig. 7-44). This valve is used to allow the operator a means to drain the air from the tanks daily, thereby preventing

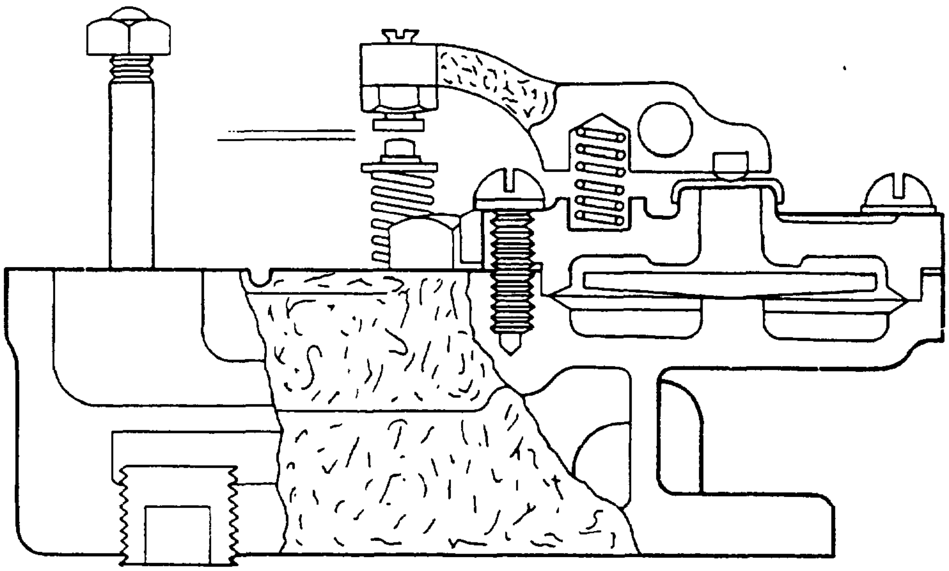


Figure 7-43.—Unloader assembly.

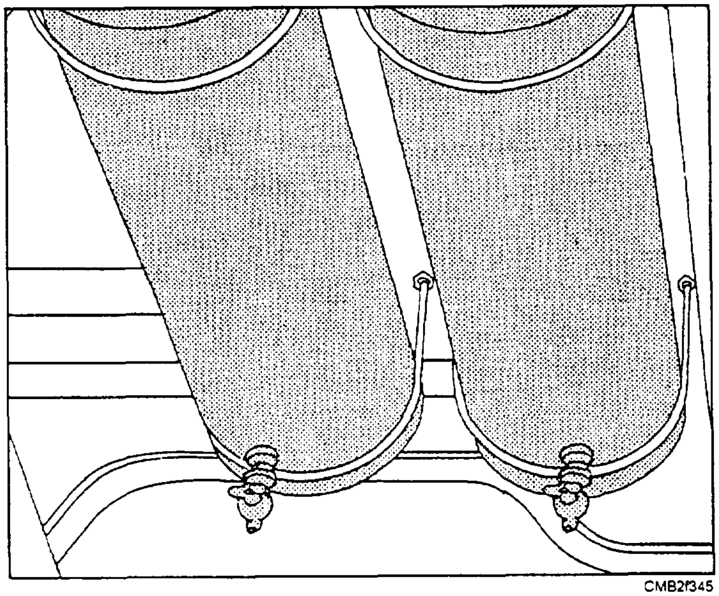


Figure 7-44.—Air reservoir with an air drain valve.

any moisture buildup in the system. Moisture in the system prevents the brakes from actuating smoothly.

A safety, valve is located on top of the first reservoir and consists of an adjustable spring-loaded bail-check valve in a body. It is used to protect the system against excessive pressures. normally set at approximately 150 psi.

BRAKE CHAMBERS

The brake chamber (fig. 7-45) converts the energy of the compressed air into mechanical force to operate the brakes. When the brake pedal is actuated, air under pressure enters the brake chamber behind the diaphragm and forces the pushrod out against the return spring force. Because the yoke on the end of the pushrod is connected to the slack adjuster, this movement rotates the slack adjuster. brake camshaft, and cam to apply the brakes.

When the pedal is released, air is forced from the brake chamber by the brake shoe return spring acting on the linkage. After the shoes reach the fully released position, the return springs acting on the diaphragm causes it to return to its original position in the chamber.

When performing maintenance of the brake system, check the brake chamber alignment to avoid binding action. Check the pushrod travel periodically, and when necessary'. adjust the brakes so that pushrod travel is as short as possible without the brakes dragging. The pushrod length should be adjusted so that the angle between the center line of the slack adjuster and the brake chamber pushrod is 90 degrees when the pushrod is extended to the center of its working stroke.

Replace the diaphragm if it is worn or leaking. Replace the boot if it is worn or cracked. With the brakes applied, cover the edges of the diaphragm and bolt with soapy water to detect leakage. If leaks are present, tighten the bolts uniformly until the leaks stop. Bolts should not be tightened so that the diaphragm shows signs of bulging or distortion.

SLACK ADJUSTERS

The slack adjusters (fig. 7-46) function as adjustable levers and provide a means of adjusting the brakes to compensate for wear of linings. Air pressure, admitted to the brake chamber when the brake pedal is depressed, moves the slack adjuster toward the position indicated by the dotted lines.

The entire slack adjuster rotates as a lever with the brake camshaft, as the brakes are applied or released. Turning the adjusting screw makes the brake adjustments necessary to maintain proper slack adjuster arm travel (shoe and drum clearance). This action rotates the worm gear, camshaft, and cam. expanding the brake shoes so that the slack caused by brake lining wear is eliminated and the slack adjuster arm travel is returned to the correct setting. The movement of the cam forces the brake shoes against the brake drum. Friction of the brake lining against the drum stops the turning movement of the wheel. When the brakes are released, the brake shoe return spring pulls the shoes back to a DISENGAGED position.

BRAKE VALVES

There are numerous brake valves used in an air brake system. These valves either apply or release air

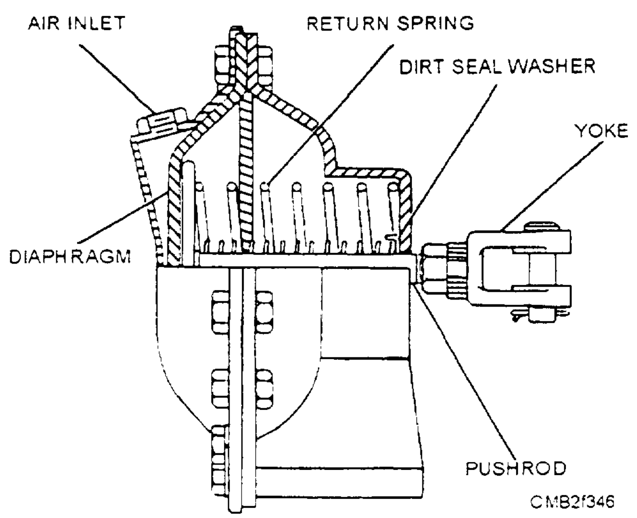


Figure 7-45.—Brake chamber.

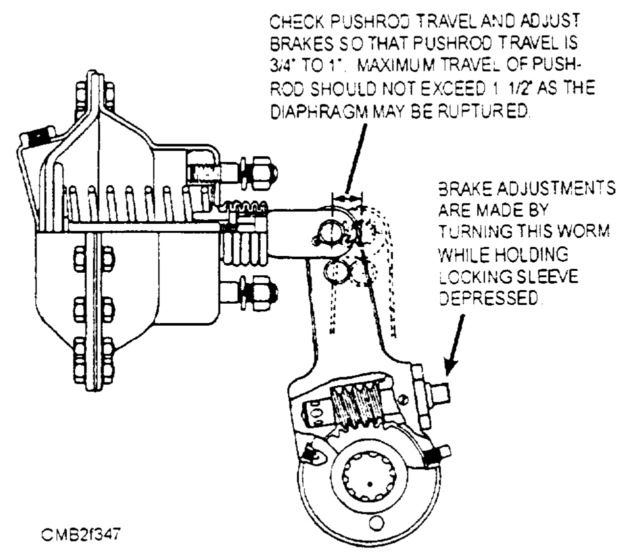


Figure 7-46.—Slack adjuster.

from the brakes and work together to ensure control and safe braking application. These valves are as follow:

- Treadle valve (brake valve)
- Trailer control valve (brake valve)
- Quick-release valve
- Combined-limiting and quick-release valve
- Tractor protection valve
- Relay emergency valve
- Check valves

In the following paragraphs we will discuss each valve in more detail.

Treadle Valve

The treadle valve (fig. 7-47) controls the air pressure delivered to the brake chambers. When the treadle valve is depressed, force is transmitted to the pressure regulating spring and diaphragm that is moved downward and contacts the exhaust valve and closes it. Continued movement opens the inlet valve and air pressure from the reservoir flows through the valve and into the delivery lines to apply the brakes. As the air pressure increases below the diaphragm, it overcomes the force above the diaphragm and the diaphragm raises slightly. This action allows the inlet valve to close but also keeps the exhaust valve closed, thereby obtaining a balanced position. Further depression of the treadle valve increases the forces above the diaphragm and correspondingly increases the delivered air pressure until a new balanced position is reached.

Maintenance of the treadle valve consists of periodic lubrication of the hinge and roller. Should the valve malfunction, it can be disassembled and cleaned. After cleaning, the internal parts should be lubricated with Vaseline before reassembly. This prevents moisture in the air system from causing corrosion and freezing of the valve. If cleaning does not remedy the malfunction, the valve must be replaced.

Figure 7-47.—Treadle valve.

Trailer Control Valve

The independent trailer control valve (fig. 7-48) provides the operator with control of the trailing load at all times. This valve functions in the same manner as the treadle valve except that the handle is turned, rather than depressed, to operate the valve.

Quick-Release Valve

The quick-release valve (fig. 7-49) exhausts brake chamber air pressure and speeds up brake release by reducing the distance the air would have to travel back to the brake valve exhaust port.

When the brakes are engaged, air from the brake valve enters into the quick-release valve, forcing the diaphragm down and closing off the exhaust port. This action allows air pressure to rush through the quick-release valve outlet ports to the wheel brake chambers. When the brakes are released, the air pressure above the quick-release diaphragm is exhausted at the brake valve. As air pressure above the diaphragm is released, the air pressure below the diaphragm raises off the exhaust port. This action allows the air in the brake chambers to exhaust at the quick-release valve.

When air is leaking from the system, a leakage test can determine if there is air leaking at the quick-release valve. The leakage test is performed with the brakes applied and coating the exhaust port with soapsuds. If air bubbles form, this is a sign of a defective valve, which can be corrected by either cleaning and replacing worn parts or by replacing the unit. Dirt, worn diaphragm, or a worn seat causes leakage.

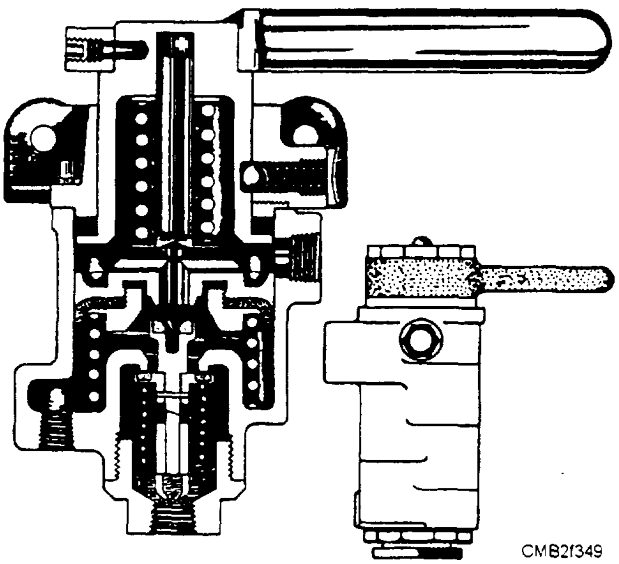


Figure 7-48.—Trailer control valve.

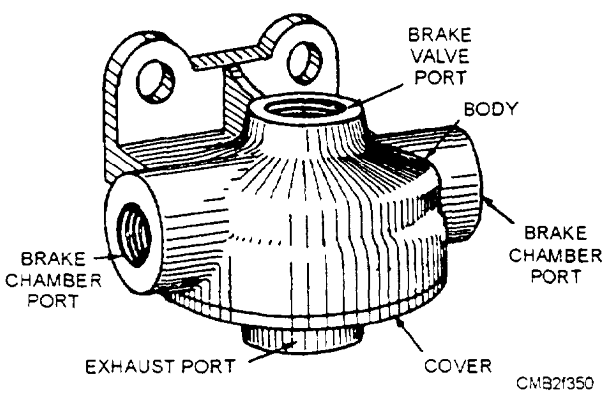


Figure 7-49.—Quick-release valve.

Combined-Limiting and Quick-Release Valve

The combined-limiting and quick-release valve (fig. 7-50) is used in combination with a two-way check valve in the air brake system of trucks and tractors. The combined-limiting and quick-release valve is interchangeable in mounting with the quick-release valve and serves the same purpose with the additional function of providing an automatic reduction of front-wheel brake pressure, at the option of the operator, on slippery roads.

Tractor Protection Valve

The primary purpose of the tractor protection valve (fig. 7-51) is to protect the tractor air brake system under trailer breakaway conditions and under conditions where severe leakage develops in the tractor or trailer.

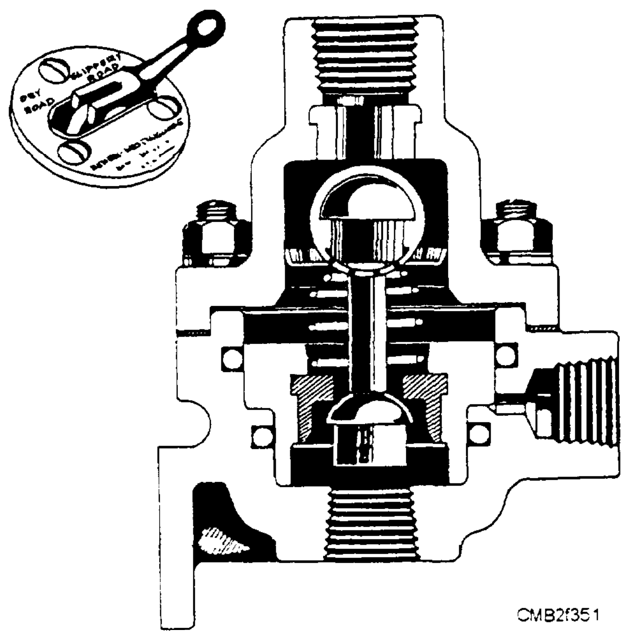


Figure 7-50.—Combined-limiting and quick-release valve.

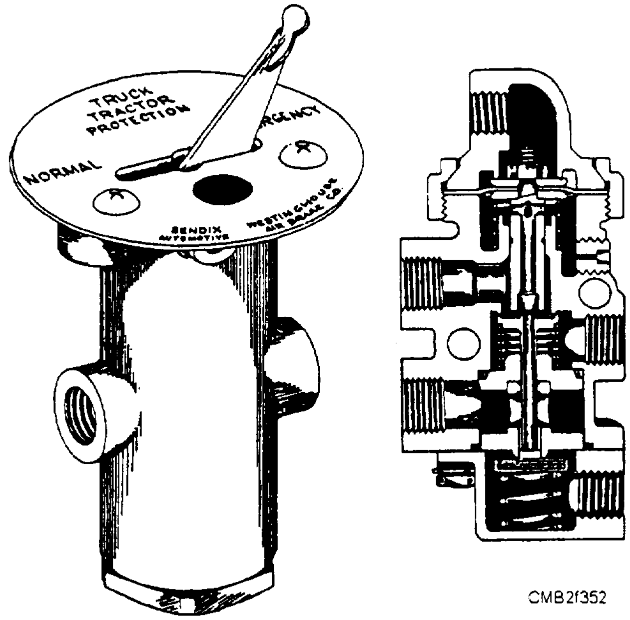


Figure 7-51.—Tractor protection valve and switch.

The tractor protection system functions as a set of remotely controlled cutout valves (fig. 7-52). The trailer service and emergency lines pass through the valve. When the control valve is in the NORMAL position, service and emergency braking functions of both the tractor and trailer are normal. When the valve lever is in the EMERGENCY position, the trailer air brakes lines are closed off.

Should acondition resulting in severe air loss from the tractor or trailer air brake system be detected or if for any other reason it is desirable to cause an emergency application of the trailer brakes, the operator can move the control valve lever to the EMERGENCY position. At this time both the trailer service and emergency brake line will be closed off at the tractor protection valve. Such operation offers a convenient daily check of the relay emergency valve on the trailer where tractors and trailers are not

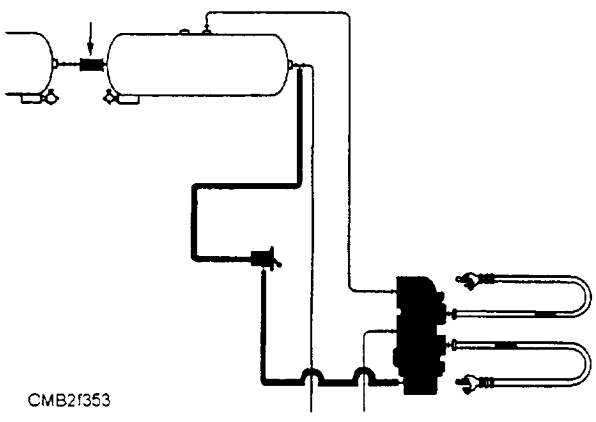


Figure 7-52.—Tractor protection valve piping.

disconnected over long periods of time. The operator should move the control to the EMERGENCY position when disconnecting a trailer or when operating a tractor without a trailer if cut-off valves are not installed in the trailer connections on the tractor. The tractor protection valve should NOT be used as a parking brake, because it was not designed for that purpose.

Relay Emergency Valve

The relay emergency valve (fig. 7-53) acts as a relay station to speed up the application and release of trailer brakes. It automatically applies the trailer brakes when the emergency line of the trailer is broken, disconnected, or otherwise vented to the atmosphere if the trailer air brake system is charged. It is used on trailers that require an emergency brake application upon breakaway from the truck or tractor.

When a tractor is connected to a trailer and the service and emergency lines are opened, the relay emergency valve permits charging the trailer air brake reservoir to approximately the same air pressure as that in the tractor reservoirs. During normal operation of a tractor-trailer unit, the relay emergency valve functions as a relay valve and synchronizes trailer service brake air pressure and tractor service brake air pressure, as the treadle valve on the tractor is operated. The trailer brakes can also be applied independently of the tractor brakes by use of the hand control on the tractor protection valve on the tractor and the relay emergency valve on the trailer.

If a trailer is disconnected from a tractor for loading or unloading or if the trailer is separated from the tractor under emergency breakaway conditions or if the emergency line of the trailer is vented to the atmosphere by other means, the relay emergency valve applies the trailer brakes. This is automatically achieved by using the existing trailer reservoir air pressure. If the trailer is to remain parked under these conditions, the wheels should be blocked to prevent the possibility of a runaway.

If you are required to release the emergency brake application on a trailer under these conditions, the trailer reservoir drain valve can be opened or the trailer air brake system can be recharged through the trailer emergency line.

You can check the relay emergency valve by moving the tractor protection valve control lever to the EMERGENCY position, if tractor protection equipment is installed. If no tractor protection is

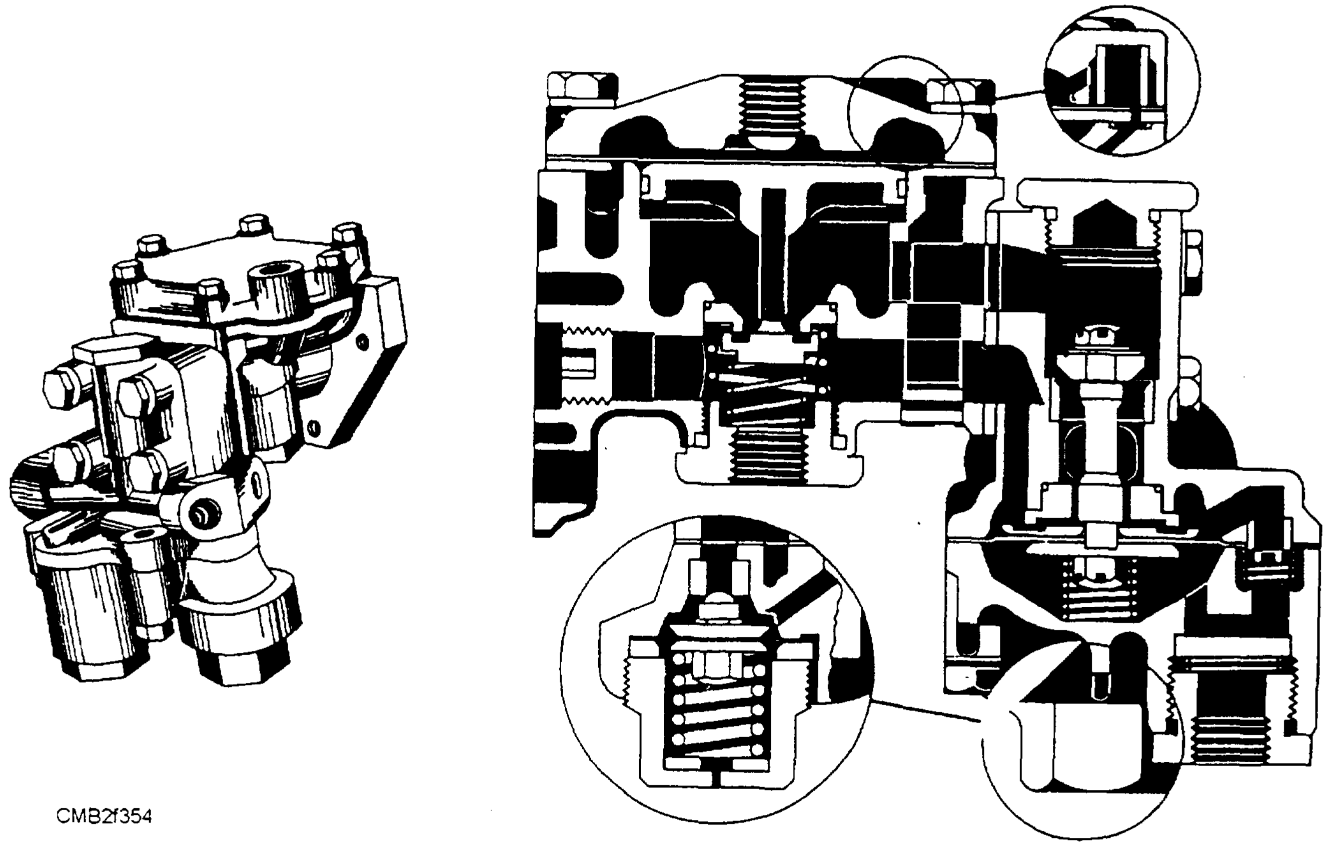


Figure 7-53.—Relay emergency valve.

installed, by closing the emergency line cutout valve and uncoupling the emergency brake line, the valve can be checked. Either way the trailer brakes should apply automatically. Trailer brakes should release, in the first case, when the tractor protection valve control lever is moved to the NORMAL position, and, in the second case, when the emergency line is coupled and the cutout valve is opened.

The relay emergency valve is checked for leakage by application of soapsuds with the brakes released. Check the emergency air line coupling with soapsuds to determine leakage with the valve in emergency application position. Leakage may be caused by dirt or worn parts which may be corrected by cleaning and/or replacing the unit.

Check Valves

Check valves are located in the lines of air brake systems to prevent the loss of air should the line rupture while in operation. These are placed at the entrance of the main air tanks and prevent the loss of air should the inlet line from the compressor fail. The ball-type check valve (fig. 7-54) is typical of the type used on trailer braking systems. Check valves may be either disc or ball and double or single units. Regardless of their design, their function is the same.

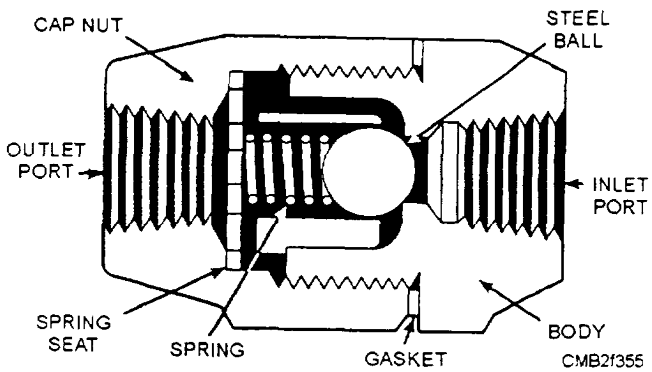


Figure 7-54.—Ball-type single check valve.

AIR HOSES AND FITTINGS

Air hoses and fittings (fig. 7-55) provide a means of making a flexible air connection between points on a vehicle which change their position in relation to each other or between two vehicles. All air brake assemblies used to connect the air brake systems from one vehicle to another are equipped with detachable fittings and spring guards.

When installing a hose assembly where both ends are permanently connected, use the air hose connector assembly at each end as the union to permit tightening the hose connectors in place. Loosen the nut on one of the connector assemblies and then turn the hose in the loose connector to avoid kinking the hose.

To prevent dirt and moisture from entering unused air lines, use dummy couplings (fig. 7-56). The two types of dummy couplings are as follows:

- Bracket-type couplings are mounted to the vehicle for storage of unused hose.
- Chain-type couplings are attached to the vehicle by a chain and placed in couplings mounted on the vehicle.

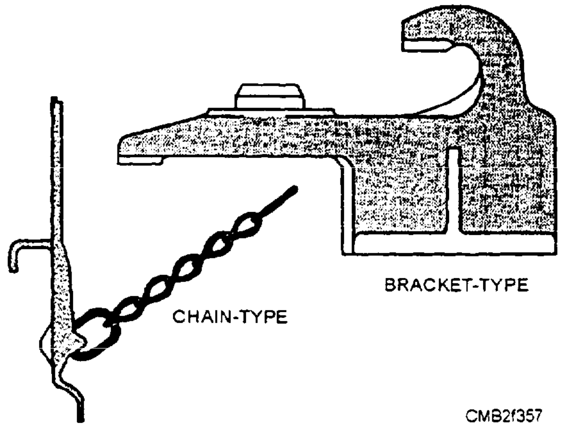


Figure 7-56.—Dummy couplings.

SYSTEM SWITCHES AND INDICATORS

The switches and indicators in an air brake system are designed as safety devices. The two most common safety devices found in an air brake system are the low-pressure warning indicator and the stoplight switch.

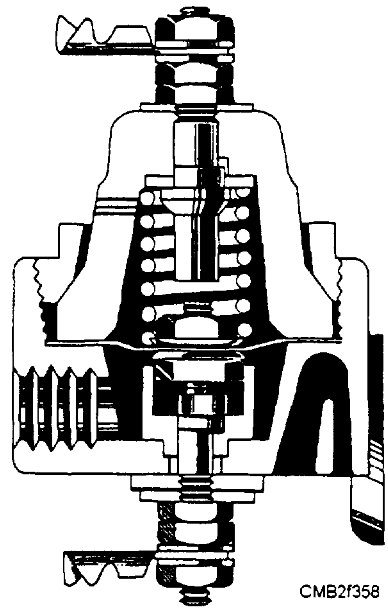


Figure 7-57.—Low-pressure warning indicator.

Low-Pressure Warning Indicator

The low-pressure warning indicator (fig. 7-57) is an electro-pneumatic switch connected with a warning buzzer and, in some designs, a warning light or both. It remains in the OPEN position when air pressure is above approximately 60 psi. When pressure drops below 60 psi, the spring forces the diaphragm down and closes the contacts, which operate the warning device. Normal operating pressure is 60 psi, plus or minus 6 pounds.

Stoplight Switches

Stoplight switches (fig. 7-58) in an air brake system are electro-pneumatic devices, which operate in conjunction with the treadle valve to close the

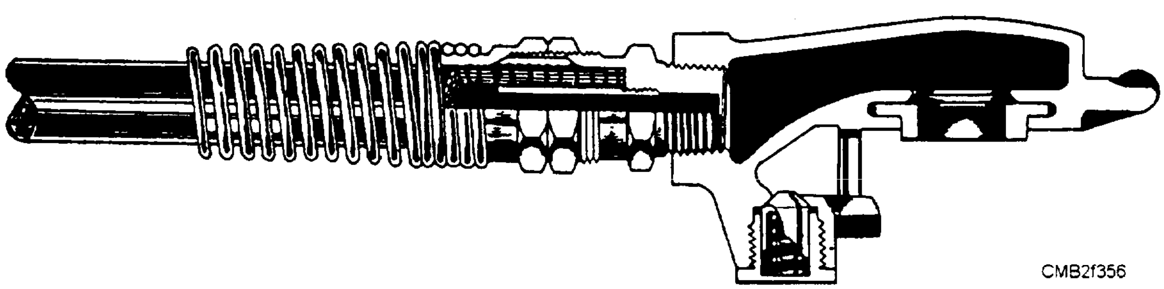


Figure 7-55.—Air hose and fittings.

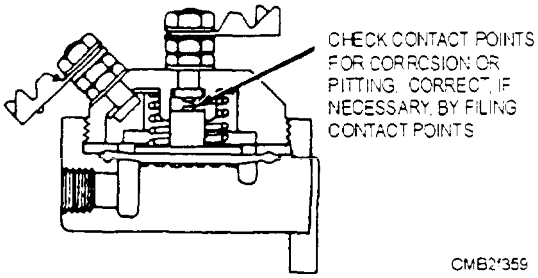


Figure 7-58.—Stoplight switch.

stoplight circuit when the brakes are applied. When air pressure from the treadle valve enters the cavity on the one side of the diaphragm, the diaphragm changes position. This action overcomes the force of the spring and moves the contact plunger until the contacts close. This closes the stoplight electrical circuit causing the brake lights to come on. The switch is designed to close as soon as 5 psi is delivered to it. This means that the stoplight circuit closes immediately on brake application.

SERVICING AIR BRAKES

Servicing is the most important part of air brake maintenance. If the air brake system is kept clean. tight, and moisture-free, brake failures will be few and far between. Particular care must be taken to keep the air compressor intake filters clean and foreign material out of the lines.

The basic test made to an air brake system is the operational test. This test may be performed on the road or in the shop. During an operational test, the brakes are applied and released while observing for equal application, sluggish engagement or release, binding linkage, and exhaust of units.

To check the leakage of the overall system, fully charge the system. shut off the ignition, and observe the pressure drop on the gauge mounted on the vehicle dash. The maximum leakage will be expressed in pounds per a specific time.

NOTE

Before making any leakage or pressure test. consult the manufacturer's specifications for correct pressure and maximum leakage.

To determine if leakage of various components is within permissible or authorized limits, use the soapsuds test. To make this test, use a thick mixture of soapsuds: do not use lye soap. This misture is applied to places in the system where leakage may occur. While some places are authorized some amount of leakage, others are not. For example, castings and the tube in the governor should have no leakage. Points with authorized leakage will have a specified maximum in pounds per a specified time.

Soapsuds can also be used to check the internal condition of a component. By covering exhaust ports or casting openings, you can check the condition of the diaphragms and valves. For example, to check the condition of the treadle valve, release the brakes and cover the exhaust ports with soapsuds. Engage the brakes: any leakage indicates the valve is not sealing properly. If the diaphragm in the brake chamber is faulty, leakage will appear around the pushrod with the brakes applied.

As with the drum brake system the linings used with air brakes gradually wear from use and require periodic adjustment or replacement. Always consult the manufacturer's specifications before making any adjustments to the air brake system. This is to ensure that the correct adjustment is made and that any variations in procedure are followed.

REVIEW 2 QUESTIONS

Q1. What are the three common methods for driving the air compressor from the engine?

Q2. What is the purpose of the governor in an air brake system?

Q3. What component controls the compressor unloading mechanism?

Q4. On a type O-1 air compressor the pressure range may be adjusted by adding or removing shims from what location?

Q5. What valve controls the air pressure delivered to the brake chambers?

Q6. What is the function of the relay emergency valve?

Q7. What component is used to prevent dirt and moisture entering unused air lines?

AIR-OVER-HYDRAULIC BRAKE SYSTEM

Learning Objective: Describe the operation, terms, and component functions of an air-over-hydraulic brake system.

The air-over-hydraulic brake system is shown in figure 7-59. This system combines the use of compressed air and hydraulic pressure for brake application. Air pressure is supplied by a compressor and stored in reservoirs as with the air brake system. The master cylinder, wheel cylinders, and brake construction are very similar to that used in a hydraulic brake system. The essential difference between the straight hydraulic brake system and the air-over-hydraulic system lies in the AIR-HYDRAULIC-POWER CYLINDER.

AIR-HYDRAULIC-POWER CYLINDER (AIR PAK)

The air-hydraulic-power cylinder (fig. 7-60) is a self-contained power brake unit. The three essential components of the air-hydraulic-power cylinder are as follows:

- The COMPRESSED AIR CYLINDER consists of a large diameter air piston operating within a cylinder body. This piston actuates a pushrod, which is attached to the hydraulic piston within the slave cylinder.

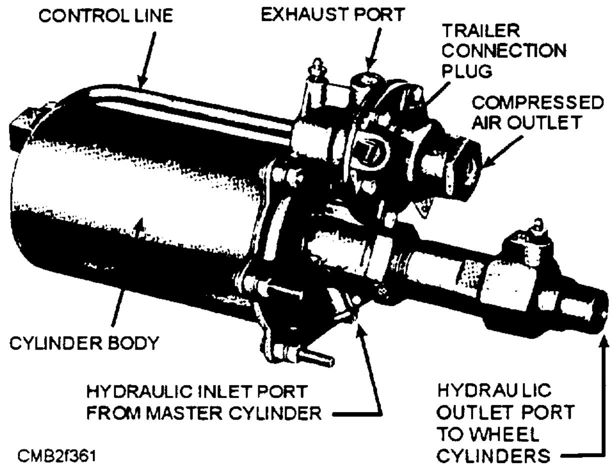


Figure 7-60.—Air-hydraulic power cylinder assembly (Air-Pak).

Movement of the piston in the compressed air cylinder is controlled by the amount of air, under pressure, that is allowed to enter through the control valve. The compressed air cylinder body is attached to the end plate on which the slave cylinder and control valve is

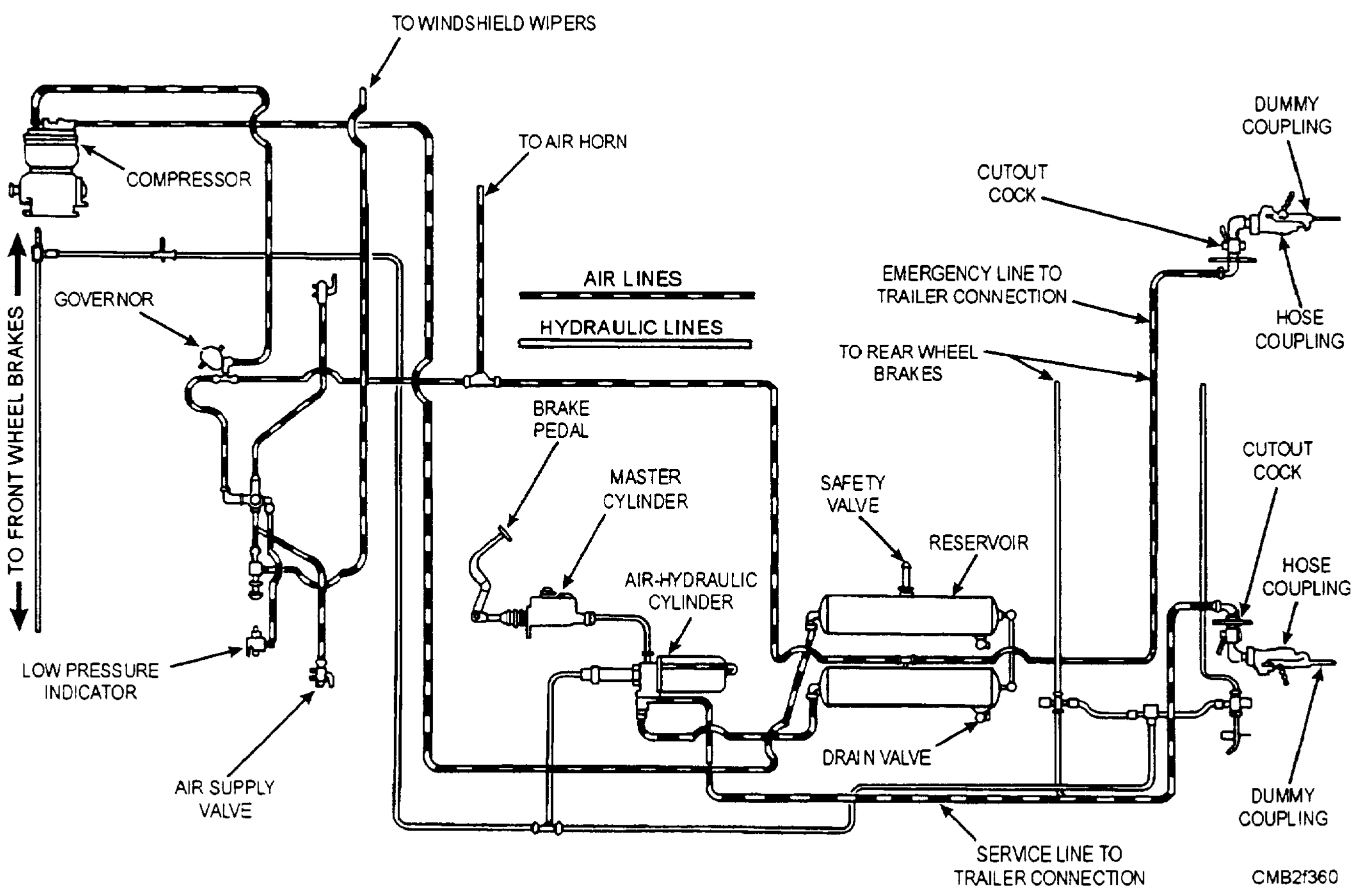


Figure 7-59.—Air-over-hydraulic brake system.

mounted. A return spring forces the power piston to the released position when the brake pedal is released.

- The SLAVE CYLINDER consists of a cylindrical housing in which a small diameter hydraulic piston operates. The outlet cap houses a residual check valve and a ball-check valve is located in the hydraulic piston.

- The CONTROL VALVE consists of two poppets operating within a housing and actuated by a hydraulic relay piston and a reactionary-type diaphragm. An air control line connects the control valve to the compressed air cylinder.

AIR-OVER-HYDRAULIC BRAKE OPERATION

The air-over-hydraulic cylinder consists of an air cylinder and hydraulic cylinder in tandem, each fitted with a piston with a common piston rod between. The air piston is of greater diameter than the hydraulic piston. This difference in areas of the two pistons gives a resultant hydraulic pressure much greater than the air pressure admitted to the air cylinder. Automatic valves. actuated by fluid pressure from the master cylinder, control the air admitted to the air cylinder. Thus fluid pressure in the brake lines is always in direct ratio to foot pressure on the brake pedal.

Figure 7-61 shows the air-hydraulic power cylinder in the released position. Views A and B show the position of the valves and slave cylinder during light and heavy brake pedal application.

When the brakes are applied, as shown in view A of figure 7-61. pressure is transmitted by the brake fluid to the hydraulic piston in the slave cylinder and the relay piston in the control valve. As hydraulic pressure builds, the relay piston moves the control valve diaphragm forward, closing the atmospheric poppet and slightly opening the air pressure poppet. Air under pressure then passes through the air control line forcing the power piston in the air cylinder forward until the air pressure on the diaphragm, in combination with spring pressure, allows the air poppet to close. The degree of brake application is determined by the amount of compressed air trapped in the power cylinder when brake pedal movement is stopped. Unless more pressure is applied or the brake pedal is released, the brakes will remain in the partially applied position.

View B of figure 7-61 shows the effect of applying high brake pedal pressure. Under this condition, the air pressure poppet is held open, allowing a full volume of compressed air to enter the air cylinder and cause full brake application.

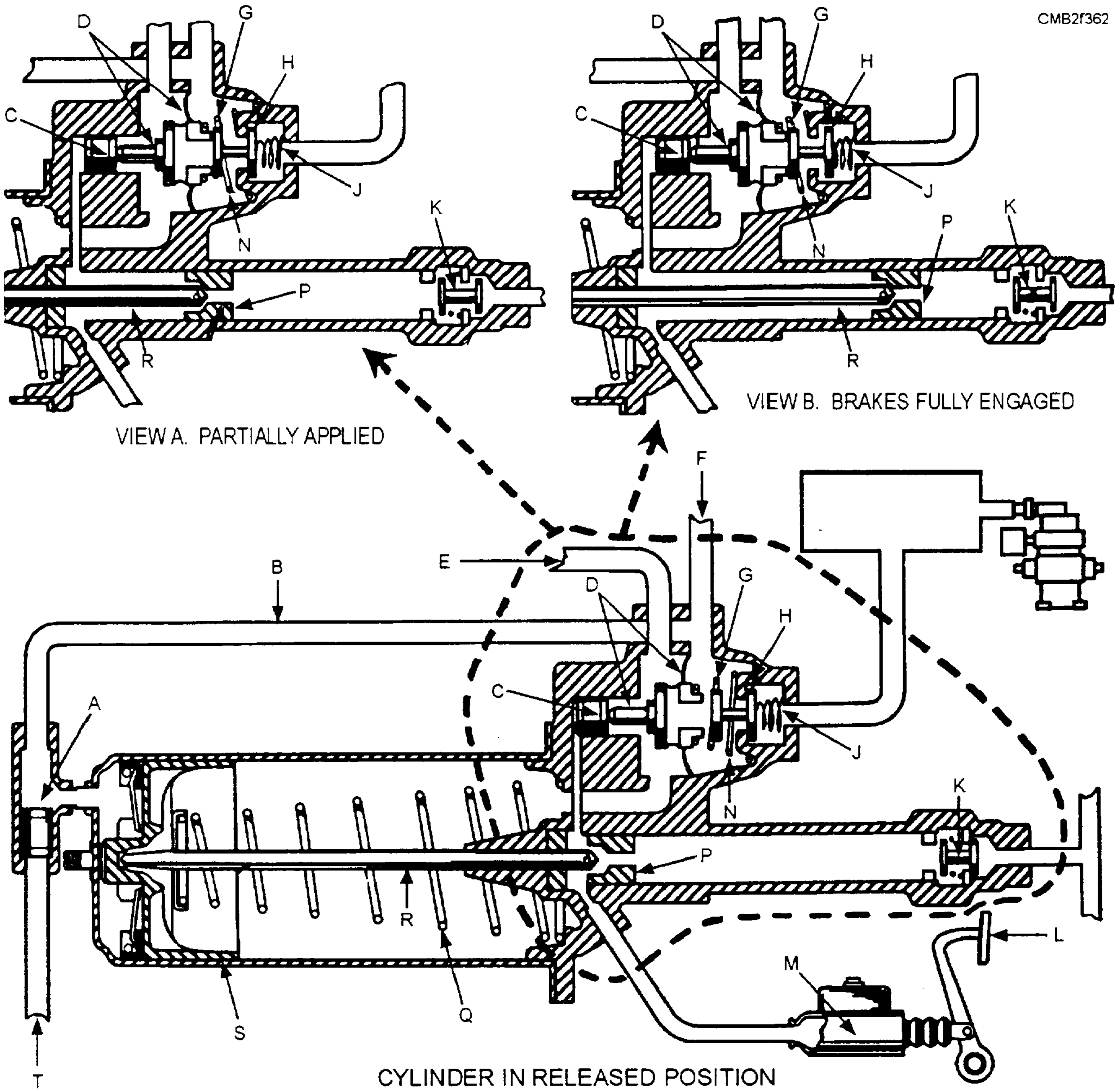
As in a conventional hydraulic brake system the residual check valve maintains a small amount of pressure in the hydraulic system when the brakes are released. This prevents the cups in the wheel cylinders from collapsing and leaking.

REVIEW 3 QUESTIONS

Q1. What are the three essential components of an air-hydraulic-power cylinder?

Q2. In what component of the air-hydraulic-power cylinder is the residual check valve located?

Q3. What action actuates the automatic valves that control the air pressure admitted to the air cylinder?



A. Double check valve assembly
B. Air control line
C. Relay piston
D. Diaphragm assembly
E. Exhaust port
F. Atmospheric inlet
G Atmospheric poppet
H. Air pressure poppet
J. Poppet return spring
K Residual line check valve assembly
L. Brake pedal
M. Master cylinder
N. Diaphragm return spring
P. Hydraulic piston
Q. Piston return spring
R. Pushrod
S. Power piston
T. Trailer connection

Figure 7-61.—Air-hydraulic power cylinder (Air-Pak) during operation.

REVIEW 1 ANSWERS

Q1. Operator reaction time

Q2. Braking ratio

Q3. 30 to 40 percent

Q4. Master cylinder

Q5. Diagonally split

Q6. Junction block

Q7. Cable type

Q8. False

Q9. Nonmetallic, semimetallic, and metallic

Q10. Caliper

Q11. Equalizes braking action at each wheel during light brake applications

Q12. A valve combing several valve junctions into a single assembly

Q13. ABS computer

Q14. Trigger wheels

Q15. True

Q16. Brake pedal free play, brake pedal height, and brake pedal reserve distance

Q17. 1/8 inch

Q18. Bench bleed the master cylinder

Q19. Brake drum micrometer

Q20. Brake disc runout

Q21. Only enough to true the disc

Q22. 10 to 15 psi

REVIEW 2 ANSWERS

Q1. Gear, belt. and chain

Q2. To maintain the air pressure in the reservoirs between maximum and minimum pressure automatically

Q3. Governor

Q4. Beneath the upper valve guide

Q5. Treadle valve

Q6. Acts as a relay station to speed up the release and application of trailer brakes

Q7 Dummy couplings

REVIEW 3 ANSWERS

Q1. Compressed air cylinder. slave cylinder, and control valve

Q2. Slave cylinder

Q3. Fluid pressure from the master cylindersed off